EN

nupigeco

PPR PIPING SYSTEM

PPR
PIPING
SYSTEM

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THE COMPANY

On October 1st 2008, two of our companies, **NUPI S.p.A.** and **GECO System S.p.A.** - both founded more than 40 years ago - merged to become **NUPIGECO S.p.A.** Combining their many years of experience and constant growth, the two firms decided to create a new flexible and advanced company, ready to play its role to satisfy the demands of the market whilst being environmentally astute.

NUPIGECO S.p.A. develops and produces pipe and fitting systems for the plumbing, heating, water pipelines, gas and irrigation fields. **Nupi Industrial Division (NUPI ID)**, which was founded in 1995, is dedicated to the production of the highest quality multilayer pipes specifically designed for the petroleum, oil, chemical and petrochemical markets.

Today, **NUPIGECO S.p.A.** offers a complete range of pipes and fittings, produced using the most modern thermoplastic materials and manufacturing processes. These product ranges are known worldwide by the following trademarks: ***NIRON, MULTINUPI, MULTIGECO, ELOFIT, ELOTHERM, ELOPRESS, POLYSYSTEM, POLIETILENE TUBI, SMARTFLEX, OILTECH, SMARTLPG, ELOSMART, SMARTCONDUIT, ELAMID, RACCORDI PVC, ECOWAVE*** and the ***ELOSFERA*** range dedicated to alternative energies: ***NRGEO*** and ***ELOSOLAR***.

These systems are known as real problem solving systems capable of supplying every kind of installation while reducing costs, avoiding wastes and increasing productivity. Thanks to their quality, these products positively fulfil the most stringent field tests and obtained the most prestigious certifications, conforming to legislation from around the globe for water, gas networks and for the conveyance of fuels.

Producing better quality and being cost effective is the goal, which is made easier every day by new technology. **NUPIGECO S.p.A.** is continuously investing in research and development programs, while strengthening the production systems, operated by a sophisticated technology that guarantees the highest quality of its products. **NUPIGECO's** market leadership enforces its role in extremely competitive and highly technological fields such as thermo transformation of plastics and polymers.

Registered Office and Headquarters - Busto Arsizio (VA)

Production Facility - Castel Guelfo di Bologna (BO)

Production Facility - Imola (BO)

APPROVALS THE COMPANY

Customers can rely on the best quality materials and precise manufacture, obtained through completely automated production systems, and continuous on time deliveries that perfectly integrate the business functions in real time. Customer satisfaction is pursued through high quality products and the constant attention to the customers' needs and requirements, and by means of an effective team of people in ***post-sales service***, effective and precise ***technical assistance*** and the ***training*** of installers.

NUPIGECO S.p.A. headquarters and production centre are located in Busto Arsizio near Milan, Italy, while the production and operation centres of Castel Guelfo and Imola are situated in strategic industrial areas near Bologna.

NUPIGECO S.p.A. is present all over the world, with manufacturing facilities, affiliated companies and warehouses in **Germany, France, Spain, Belgium, UK, China, Brazil, U.S.A.** and **UAE**.

kiwa Partner for progress — UNI EN ISO 9001

kiwa Partner for progress — UNI EN ISO 14001

kiwa Partner for progress — OHSAS 18001

ACTIVITY

Industrial avant-garde
in the transport of
liquid and gaseous fluids
using systems made
of plastic material

Sanitary systems
Heating systems
Water networks
Gas pipelines
Irrigation
Transport of food fluids
Conditioning
Cooling
Industrial installations
Petroleum industry
Chemical industry
Petrochemical industry

WHO WE ARE

Our numbers

- Present in the market for more than 40 years
- 22 product lines
- 300 employees
- 3 production plants in Italy
- 3 production plants worldwide (U.S.A., Brazil, China)
- 26 extrusion lines in Italy, 4 lines in the U.S.A., 3 lines in China and 2 lines in Brazil
- 40 injection molding machines for the production of fittings
- 9 warehouses in Europe and the rest of the world (Germany, France, Spain, Belgium, UK, U.S.A., Brazil, China, UAE)
- 10% of turnover invested in R & D
- 150,000 square meters of surface area occupied by NUPIGECO in the world

Our strengths

- Exports established in more than 70 countries in 5 continents
- Worldwide after-sales assistance
- R & D department dedicated to Internal Development, Technical Support, After-Sales Service
- Production of pipes and fittings from ø12 to ø1000
- Training center for each authorized distributor

PPR
PIPING SYSTEM

1

PPR PIPING SYSTEM

PPR PIPING SYSTEM

PPR PIPING SISTEM

PPR PIPING SYSTEMS allow the creation of mechanical installations suitable for carrying liquids under pressure.

It is too simple to consider PPR just as a carrier of sanitary fluids such as drinking water, heating, water supply and sewage, as new coextrusion technologies allow to produce pipes that can be used in particularly difficult conditions in terms of:

1) **chemical attack from transported fluids** - cooling towers or new generation biocide agents with a high percentage of chlorine;

2) **high operating pressures**;

3) **high volumetric flow rates** required for the air-conditioning of large buildings.

Consider the evolution of raw materials (classified degrees MRS 8, MRS 10 and MRS 12,5) and the techniques of thickness coextrusion that can increase the useful life of pipelines, from simple 3-layer pipes with fiber glass inner layer at different percentages that minimizes the thermal expansion caused by the transport of fluid at high temperatures, to the most complex multilayer pipelines designed to increase the resistance to degradation caused by UV rays and/or strong oxidizing chemical agents (Cl_2, ClO_2, ozone etc.).

PPR PIPING SYSTEM

MONOLAYER PIPE									
OD		SDR 6 - S 2,5				SDR 7,4 - S 3,2			
In	mm	Th	ID	kg/m	liter/m	Th	ID	kg/m	liter/m
	16	2,7	10,60	0,11	0,09				
1/2″	20	3,4	13,20	0,17	0,14				
3/4″	25	4,2	16,60	0,26	0,22	3,5	18,00	0,23	0,25
1″	32	5,4	21,20	0,43	0,35	4,4	23,20	0,37	0,42
1 1/4″	40	6,7	26,60	0,66	0,56	5,5	29,00	0,57	0,66
1 1/2″	50	8,4	33,20	1,03	0,87	6,9	36,20	0,88	1,03
2″	63	10,5	42,00	1,62	1,38	8,7	45,60	1,39	1,63
2 1/2″	75	12,5	50,00	2,29	1,96	10,4	54,20	1,98	2,31
3″	90	15,0	60,00	3,30	2,83	12,5	65,00	2,83	3,32
4″	110	18,4	73,20	4,92	4,21	15,2	79,60	4,25	4,97
	125	20,8	83,40	6,30	5,46	17,1	90,80	5,41	6,47
6″	160					21,9	116,20	8,79	10,60
8″	200					27,4	145,20	13,70	16,55
	250					34,2	181,60	21,25	25,89
10″	315								
	355								
16″	400								
	450								
20″	500								
	560								
24″	630								

MONOLAYER PIPE									
OD		SDR 11 - S 5				SDR 9 - S 4			
In	mm	Th	ID	kg/m	liter/m	Th	ID	kg/m	liter/m
	16								
1/2″	20								
3/4″	25								
1″	32	2,9	26,20	0,26	0,54	3,6	24,80	0,31	0,48
1 1/4″	40	3,7	32,60	0,40	0,83	4,5	31,00	0,48	0,75
1 1/2″	50	4,6	40,80	0,63	1,31	5,6	38,80	0,74	1,18
2″	63	5,8	51,40	0,99	2,07	7,1	48,80	1,17	1,87
2 1/2″	75	6,8	61,40	1,37	2,96	8,4	58,20	1,65	2,66
3″	90	8,2	73,60	1,99	4,25	10,1	69,80	2,38	3,82
4″	110	10,0	90,00	2,96	6,36	12,3	85,40	3,54	5,73
	125	11,4	102,20	3,84	8,20	14,0	97,00	4,58	7,39
6″	160	14,6	130,80	6,22	13,43	17,9	124,20	7,46	12,11
8″	200	18,2	163,60	9,76	21,01	22,4	155,20	11,57	18,91
	250	22,7	204,60	15,00	32,86	27,9	194,20	17,96	29,61
10″	315	28,6	257,80	23,70	52,17	35,2	244,60	28,36	46,97
	355	32,2	290,60	30,00	66,29	39,7	275,60	35,95	59,62
16″	400	36,3	327,40	38,20	84,14	44,7	310,60	45,50	75,73
	450	40,9	368,20	48,10	106,42				
20″	500	45,4	409,20	59,10	131,44				
	560	50,8	458,40	74,00	164,95				
24″	630	57,2	515,60	93,50	208,69				

VALUES AS PER STANDARDS	DIN 8077	ISO 15874
	ISO 4065	

OD	Outside Diameter
Th	Thickness
ID	Inside Diameter
kg/m	Kilogram per meter
liter/m	Liters per meter
SDR	Standard Dimension Ratio
S	Series (SDR-1)/2

VALUES AS PER STANDARDS	DIN 8077	ISO 15874
	ISO 4065	

OD	Outside Diameter
Th	Thickness
ID	Inside Diameter
kg/m	Kilogram per meter
liter/m	Liters per meter
SDR	Standard Dimension Ratio
S	Series (SDR-1)/2

FIBER GLASS COEXTRUDED PIPE

OD		SDR 7,4 - S 3,2				SDR 9 - S 4			
In	mm	Th	ID	kg/m	liter/m	Th	ID	kg/m	liter/m
1/2"	20	2,8	14,40	0,16	0,16				
3/4"	25	3,5	18,00	0,24	0,25				
1"	32	4,4	23,20	0,39	0,42	3,6	24,80	0,33	0,48
1 1/4"	40	5,5	29,00	0,59	0,66	4,5	31,00	0,51	0,75
1 1/2"	50	6,9	36,20	0,91	1,03	5,6	38,80	0,78	1,03
2"	63	8,6	45,80	1,45	1,63	7,1	48,80	1,24	1,87
2 1/2"	75	10,3	54,40	2,06	2,31	8,4	58,20	1,74	2,66
3"	90	12,3	65,40	2,94	3,32	10,1	69,80	2,51	3,82
4"	110	15,1	79,80	4,36	4,97	12,3	85,40	3,73	5,73
	125	17,1	90,80	5,61	6,47	14,0	97,00	4,82	7,39
6"	160	21,9	116,20	9,09	10,60	17,9	124,20	7,83	12,11
8"	200	27,4	145,20	14,23	16,55	22,4	155,20	12,00	18,91
	250	34,2	181,60	22,80	25,89	27,9	194,20	18,70	29,61
10"	315	43,1	229,80	34,89	39,39	35,2	244,60	29,50	46,97
	355	48,5	259,00	44,16	51,45	39,7	275,60	37,40	59,62
16"	400	54,7	290,60	56,00	65,38	44,7	310,60	47,30	75,73
	450								
20"	500								
	560								
24"	630								

FIBER GLASS COEXTRUDED PIPE

OD		SDR 11 - S 5				SDR 17 - S 8			
In	mm	Th	ID	kg/m	liter/m	Th	ID	kg/m	liter/m
1"	32	2,9	26,20	0,28	0,54				
1 1/4"	40	3,7	32,60	0,43	0,83				
1 1/2"	50	4,6	40,80	0,67	1,31				
2"	63	5,8	51,40	1,04	2,07				
2 1/2"	75	6,8	61,40	1,44	2,96				
3"	90	8,2	73,60	2,08	4,25				
4"	110	10,0	90,00	3,10	6,36				
	125	11,4	102,20	4,02	8,20				
6"	160	14,6	130,80	6,50	13,43	9,5	141,00	4,65	15,61
8"	200	18,2	163,60	10,09	21,01	11,9	176,20	6,90	24,37
	250	22,7	204,60	15,01	32,86	14,8	220,40	10,68	38,13
10"	315	28,6	257,80	24,67	52,17	18,7	277,60	16,91	60,49
	355	32,2	290,60	31,20	66,29	21,1	312,80	21,39	76,81
16"	400	36,3	327,40	39,51	84,14	23,7	352,60	27,03	97,60
	450								
20"	500								
	560								
24"	630								

Drinking water	HVACR	Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
●	●	●	●		●	●	●	●

•	Not at all satisfactory
••	Unsatisfactory
•••	Rather satisfactory
••••	Very satisfactory
•••••	Extremely satisfactory

CHARACTERISTICS	STEEL	COPPER	PPR PIPING SYSTEM BY NUPIGECO
Corrosion resistance	••••	••••	•••
Available sizes	••	••	•••••
Types of junction	•••	•••	••••
Efficiency of the junction	••••	••••	•••••
Installation time	•••	•••	•••••
Anti-condensation insulation thickness	•••	•••	••••
Impact strength	••••	•••	•••••
Crack propagation	••••	•••	•••
Chemical resistance	•••••	••••	••••
Hygiene & potability	••	••	•••••
Durability	••••	••••	••••
Eco friendly	•	•	•••••
Installation costs	••	•••	•••••
Surface smoothness and head loss	•••	•••	••••
Available sizes	•••	•••	••••
Suitability in cold areas	••••	••••	••••

N.B. For more information, see the chemical compatibility table at the end of the catalogue

PPR PIPING SYSTEM

Mechanical properties

PPR

Parameter	UM	Requirements	Test parameters	Test method
Internal pressure resistance	h	> 1	T=20C =16MPa	EN ISO 1167
Internal pressure resistance	h	> 22	T=95C =4,3MPa	EN ISO 1167
Internal pressure resistance	h	> 165	T=95C =3,8MPa	EN ISO 1167
Internal pressure resistance	h	> 1000	T=95C =3,6MPa	EN ISO 1167

PP-RP

Parameter	UM	Requirements	Test parameters	Test method
Internal pressure resistance	h	> 1	T=20C =15MPa	EN ISO 1167
Internal pressure resistance	h	> 22	T=95C = 4,2MPa	EN ISO 1167
Internal pressure resistance	h	> 165	T=95C = 4,0MPa	EN ISO 1167
Internal pressure resistance	h	> 1000	T=95C = 3,8MPa	EN ISO 1167

Physical properties

PPR and PP-RP

Parameter	UM	Requirements	Test parameters	Test method
Heat shrink	%	<2	T= 135C e8 mm --> t = 1 h 8<e16 mm --> t = 2 h e>16 mm --> t = 4 h	EN743 Method B
Resistance to impact	%	no break	T= 0C	ISO/DIS 9854
MFI	%	30, max difference between pipe and MP	T= 230C m= 2,16 Kg	ISO 1133 CONDITION 12 / UNI5640/74

PPR

Parameter	UM	Requirements	Test parameters	Test method
Thermal stability through pressure tests	h	>8760	=1,9 Mpa - T=110C	EN ISO 1167

PP-RP

Parameter	UM	Requirements	Test parameters	Test method
Thermal stability through pressure tests	h	>8760	=2,3 Mpa T=110C	EN ISO 1167

Physical properties of the raw material				
PPR and PP-RP				
	UM	**Requirements**	**Test parameters**	**Test method**
Modulus of elasticity	MPa	850-900	1 mm/min	ISO 527-2
MFI	g/10’	0,2-0,3	T= 230C - m= 2,16 Kg	ISO 1133
MFI	g/10’	0,4-0,5	T= 190C - m=5,0 Kg	ISO 1133

PPR PIPING SYSTEM

TECHNOLOGY AND APPLICATIONS

	Monolayer pipe	Fiber glass	Preinsulated	Oxygen barrier	UV barrier	Chemical barrier
Drinking water	■					
Heating systems		■				
Heating/cooling systems		■		■		
Radiant systems		■				
Industrial cooling		■	■	■		■
Industrial heating		■	■	■		■
Chilled water technology		■				
Cooling towers		■				■
Agriculture	■				■	
Swimming pools		■		■		■
Chemical fluid conveyance						■
Transport of chlorine						■
Rainwater and recycled water	■					
Irrigation	■					
Ship building	■	■			■	
District heating pipeline systems		■	■			
Compressed air systems		■				
Geothermal systems	■	■	■			

■	The system is suitable for this application

HOW TO READ THE TABLE

The table shows which technology to use, depending on the applications. Once you select the box that represents the APPLICATION, you can find the TECHNOLOGY to be used following the line corresponding to the selected box.

The choice can sometimes be multiple, as more than one product can satisfy the requirements of the same application. The solutions proposed by NUPIGECO meet the pressure values and the characteristics of the liquid to be transported, allowing the installation of major projects (airports, shopping malls, air conditioning systems) and the most common household plumbing installations.

PPR PIPING SYSTEM

Drinking water distribution networks

The system allows the transport of hot and cold drinking water.

Systems for central thermal regulation

Installations in large civil and industrial buildings for commercial or residential use that require the vertical distribution of piping for the transport of the fluid.

Air handling units and rooftop units

Systems designed to ensure the perfect installation of connections between large climatic rooms and main manifolds for the distribution of chilled fluids.

Chilled water is used to cool the air in a building and the equipment for refrigeration units, especially when many individual rooms must be separately controlled (e.g. a hotel).

Chilled water is produced by an individual unit sized according to the dimensions of the room to serve. The advantage provided by the size of the refrigeration unit is based on the principles of the economy of scale.

As a consequence, the greater the size of the refrigeration unit, the lower its power consumption. According to these considerations, it is necessary to rely on a PPR pipe and fitting system that can fulfil saving requirements in terms of piping insulation, heat transmission, installation times and head loss.

Thanks to the **PPR PIPING SYSTEM** by **NUPIGECO**, commercial buildings can lower installation costs by up to 20%.

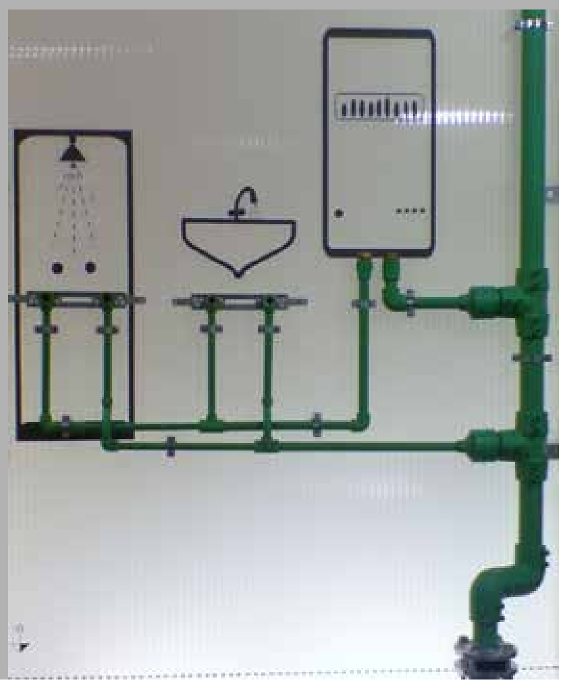
VERSATILE HORIZONTAL AND VERTICAL INSTALLATIONS

RISERS

Hot and cold water distribution networks made with vertical risers in the following configurations:

- water distribution from public water pipelines to apartment blocks;
- branching pattern;
- horizontal ring pattern;
- cage pattern.

TERMINATING COLLECTION POINTS



PPR PIPING SYSTEM

COOLING TOWERS: used to dispose of unwanted heat produced by a cooler. Big office buildings, hospitals and schools typically use one or more cooling towers as part of their air conditioning systems. Industrial and commercial cooling towers are used to remove the heat of the production process. The main aim of large industrial cooling towers is to eliminate the heat absorbed by the circulating system for cooling water.

PUMP ROOMS

Class 1 pipes and fittings used for the mechanical units adopted that shall always be designed RESPECTING PPR PRESSURE CLASSES: centrifugal pumps, multi-stage pumps, wet rotor pumps, impellers, magnet dynamic fluid pumps, axial pumps, hydraulic water hammer pumps, linear dynamic fluid pumps.

PPR PIPING SYSTEMS FOR THE TRANSPORT OF FLUIDS UNDER PRESSURE AND AGGRESSIVE FLUIDS

Mining industry
Iron and steel industry
Metallurgy industry
Chemical industry
Pharmaceutical industry
Defense industry

Mechanical industry
Engineering industry
Automotive industry
Motorcycle industry
Petrochemical industry
Ship building industry

Manufacturing industry
Textile industry
Woodworking industry and paper mills
Food industry
Livestock industry
Construction material industry

Installations on MARINE VESSELS such as passenger ships, motorboats, cruise ships, ferries, oil tankers, merchant ships, container ships and leisure boats.

NIRON®
PURPLE PPR PIPE

WATER RECYCLING SYSTEMS

The **water average consumption** of a four person individual house in a temperate climate is over **200.000 liters per year**, around 17.000 liters per month.

Waste water or rainwater is routed to a central sump basin to be recycled. The sump then moves the water through some filtration stages and starts a disinfection cycle before it enters the storage tank. On a pre-determined schedule, a timer controlled pump recirculates water in the storage tank through the entire filtration process to maintain it clear and bacteria free. Recycled water in the storage tank is drawn out by a pressure regulated pump. When the irrigation timer turns on or a toilet is flushed, the system automatically provides the recycled water stored in the storage tank. When the storage tank is full, excess water drains into the sewage system.

For commercial building owners the need to **store water** is a **mandatory requirement**. Additionally, it is just the right thing to do, both from a financial and environmental point of view.

Resort, hotel and shopping mall owners who have to deal with a **high number of visitors** are increasing water storage especially in arid climates where lush foliage and landscaping is mandatory for visitors.

In the near future, the use of recycled water will have a huge impact on operating costs and profitability. Therefore, **PPR PIPING SYSTEM** by **NUPIGECO** offers to its users a piping range that allows the building of this type of installations.
The **PURPLE** colour is in accordance with international standards regarding “waste and recycled water systems” and allows the pipe to be immediately identified.

	HVACR			H2O				
Drinking water		Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
				●				

SISTEMA NIRON FG

NIRON Clima

Polysystem NIRON FG

PPR AND FIBER GLASS

Pipes made of polypropylene with an inner layer made also of fiber glass are visually characterized by coextrusion lines of different colour and are composed of several layers.

The inner and outer layers are made of Polypropylene Random Copolymer with an MRS of 10, while the intermediate layer is composed of a particular heterophasic PPR containing a given percentage of fiber glass.

The intermediate layer including fiber glass makes the product more dimensionally stable to thermal shock.

The technological contribution of the glass fibers consists especially in the ***LOWER THERMAL EXPANSION*** and the ***HIGHER RESISTANCE TO COMPRESSION*** with a significantly lower tendency to distortion.

These pipes are available in 4m, 5,8m or 11,6m bars.

	HVACR							
Drinking water		Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
	●	●			●	●	●	●

SYSTEM TESTING

The installation must be tested according to the European standards CEN TR 12108 and EN 806-4.

PPR PIPING SYSTEM pipes with fiber glass (NIRON CLIMA, NIRON FG, POLYSYSTEM NIRON FG) have been specially designed to meet the needs of air conditioning systems.

They are suitable for installations where the presence of chilled water is predominant but also for installations where the values of temperature and nominal pressure rates of fluids are close to the limits of performance ranges.

The system is **IN ACCORDANCE WITH CURRENT REGULATIONS ABOUT THE SALUBRITY OF WATER** that regulate the hygienic and sanitary criteria for the prevention and control of Legionellosis and bacterial proliferation in general.

REGULATIONS AND CERTIFICATES

The system is completely non-toxic and fully meets the hygienic-sanitary standards in force to safeguard the health of users.

PPR pipes with fiber glass are produced respecting German regulations DIN 8077/78 DIN 16962, as well as the international standard UNI EN ISO 15874 for the production of polypropylene pipes and fittings for the conveyance of hot and cold water for domestic use.

They also conform to the circular letter no. 174 of the Italian Ministry of Health dated 6th April 2004.

PPR PIPING SYSTEMS WITH FIBER GLASS are currently the **most suitable solution** to the **problems caused by metal installations** thanks to the following characteristics:

- **LOW HEAT TRANSMISSION**
- **LIMITED HEAT LOSS AND CONDENSATION**
- **100% CORROSION RESISTANT**
- **LOWER SURFACE ROUGHNESS**
- **ACOUSTIC ABSORPTION AND INSULATION**
- **HIGH CHEMICAL RESISTANCE**
- **INSTALLATION TIME SAVING**
- **TOTALLY RECYCLABLE AND ECO-FRIENDLY**
- **HIGH RESISTANCE TO IMPACT AND ABRASION**
- **LIMITED THERMAL EXPANSION**
- **TOTALLY COMPATIBLE WITH TREATMENTS AGAINST THE LEGIONELLOSIS BACTERIA**

STEEL PIPE DIMENSIONS

	STEEL PIPE IN ACCORDANCE WITH UNI ISO7/1 - UNI ISO 50			
DN	OD mm	ID mm	Th mm	w kg/m
16	17,2	**12,6**	2,3	0,90
20	21,3	**14,70**	3,3	1,29
25	26,9	**18,30**	4,3	1,66
32	33,7	**23,10**	5,3	2,57
40	42,4	**29,80**	6,3	3,31
50	48,3	**33,70**	7,3	3,81
63	60,3	**43,70**	8,3	5,40
75	76,1	**57,50**	9,3	6,93
90	88,9	**68,30**	10,3	9,03
110	114,3	**91,70**	11,3	13,00
125	139,7	**115,10**	12,3	17,30
160	165,1	**138,50**	13,3	20,80
200				
250				
315				
355				
400				
450				
500				
560				
630				

	STEEL PIPE IN ACCORDANCE WITH EN 12208			
DN	OD mm	ID mm	Th mm	w kg/m
16				
20				
25				
32				
40				
50				
63	60,3	**54,50**	2,9	4,11
75	76,1	**70,30**	2,9	5,24
90	88,9	**83,10**	2,9	6,15
110	114,3	**107,90**	3,2	8,77
125	139,7	**132,50**	3,6	12,10
160	168,3	**160,30**	4,0	16,20
200	219,1	**209,10**	5,0	26,40
250	273	**261,80**	5,6	36,90
315	323,9	**312,10**	5,9	46,30
355	355,6	**343,00**	6,3	54,30
400	406,4	**393,80**	6,3	62,20
450	457	**444,40**	6,3	70,00
500	508	**495,40**	6,3	77,90
560				
630	610	**595,80**	7,1	123,00

DN NOMINAL DIAMETER
OD OUTSIDE DIAMETER
ID INTERNAL DIAMETER
Th THICKNESS
w WEIGHT

PPR PIPE DIMENSIONS

DN	PPR PIPING SYSTEM FIBER GLASS SDR 7,4 S 3,2- UNI EN ISO 15874			
	OD mm	ID mm	Th mm	w kg/m
16				
20	20	**14,40**	2,8	0,16
25	25	**18,00**	3,5	0,24
32	32	**23,20**	4,4	0,39
40	40	**29,00**	5,5	0,59
50	50	**36,20**	6,9	0,91
63	63	**45,80**	8,6	1,45
75	75	**54,40**	10,3	2,06
90	90	**65,40**	12,3	2,94
110	110	**79,80**	15,1	4,36
125	125	**90,80**	17,1	5,61
160	160	**116,20**	21,9	9,09
200	200	**145,20**	27,4	14,73
250	250	**181,60**	34,2	22,08
315	315	**229,80**	42,6	34,89
355	355	**259,00**	48,5	44,16
400	400	**290,60**	54,7	56,00
450				
500				
560				
630				

DN	PPR PIPING SYSTEM - CLIMA SDR 9 S 4- UNI EN ISO 15874			
	OD mm	ID mm	Th mm	w kg/m
16				
20				
25				
32	32	**24,80**	3,6	0,33
40	40	**31,00**	4,5	0,51
50	50	**38,80**	5,6	0,78
63	63	**48,80**	7,1	1,24
75	75	**58,20**	8,4	1,74
90	90	**69,80**	10,1	2,51
110	110	**85,40**	12,3	3,73
125	125	**97,00**	14,0	4,82
160	160	**124,20**	17,9	7,83
200	200	**155,20**	22,4	12,00
250	250	**194,20**	27,9	18,70
315	315	**244,60**	35,2	29,50
355	355	**275,60**	39,7	37,40
400	400	**310,60**	44,7	47,30
450				
500				
560				
630				

DN	PPR PIPING SYSTEM - CLIMA SDR 11 S 5- UNI EN ISO 15874			
	OD mm	ID mm	Th mm	w kg/m
16				
20				
25				
32	32	**26,20**	2,9	0,28
40	40	**32,60**	3,7	0,43
50	50	**40,80**	4,6	0,67
63	63	**51,40**	5,8	1,04
75	75	**61,40**	6,8	1,44
90	90	**73,60**	8,2	2,08
110	110	**90,00**	10,0	3,10
125	125	**102,20**	11,4	4,02
160	160	**130,80**	14,6	6,50
200	200	**163,60**	18,2	10,09
250	250	**204,60**	22,7	15,01
315	315	**257,80**	28,6	24,67
355	355	**290,60**	32,2	31,20
400	400	**327,40**	36,3	39,51
450				
500				
560				
630				

DN NOMINAL DIAMETER
OD OUTSIDE DIAMETER
ID INTERNAL DIAMETER
Th THICKNESS
w WEIGHT

SISTEMA NIRON® COLLETTORI

DISTRIBUTION MANIFOLDS

Nowadays, more and more companies choose PPR manifolds.

Installations are often required to serve high flow rates and their weight and implementation difficulties require special expensive equipment.

NUPIGECO produces a wide range of welding saddles that allows the construction of distribution manifolds in just a few steps.

The company also provides a technical service whose task is to make and test the manifolds needed for a specific project as per customers' needs according to water tightness tests as per CEN TR 12108.

The company's Plumbing Division has a special department dedicated to these manifolds and equipped with specific equipment and programs for their design and making according to customers' requirements. This department offers assistance during the installation and facilitates the work of project managers and installation professionals thanks to the versatility offered by **PPR PIPING SYSTEM** by **NUPIGECO**.

Drinking water	HVACR	Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
●	●	●	●			●	●	●

NIRON® PREISOLATO

It is the innovative PRE-INSULATED pipe and fitting system that is ideally suitable for application in areas where the heat loss reduction is essential.

This product range was specifically designed for networks for the distribution or adduction of hot fluids.

The reliability, ease of installation and relevant physical-mechanical properties of the materials used allow installers to overcome many problems when installing heat distribution and conditioning systems.

THERMAL INSULATION (PUR)

The insulation of the primary pipe is made with a rigid polyurethane foam according to EN 253 standard and is free from Freon. The coefficient of thermal conductivity is 0,027 W/mK at a medium temperature of 50°C.

This excellent characteristic of the material allows to obtain high levels of thermal insulation with significantly reduced insulation layers if compared to those that would be required if other materials were to be used.

In addition, due to its closed cell structure, under normal conditions of use it does not have any transformation caused by water absorption, compression, sacking, etc.

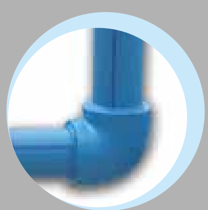
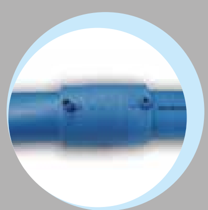
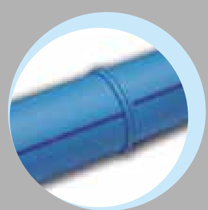
JACKET PIPE (HDPE)

The layer of polyurethane insulation is protected by a jacket pipe made of High Density Polyethylene (HDPE) according to EN 253.

	HVACR							
Drinking water		Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
●	●		●			●	●	●

APPLICATIONS

- District heating/cooling
- Transport of energy on site and remote
- Transport of water
- Cooling systems
- Geothermal systems
- Industry and agriculture

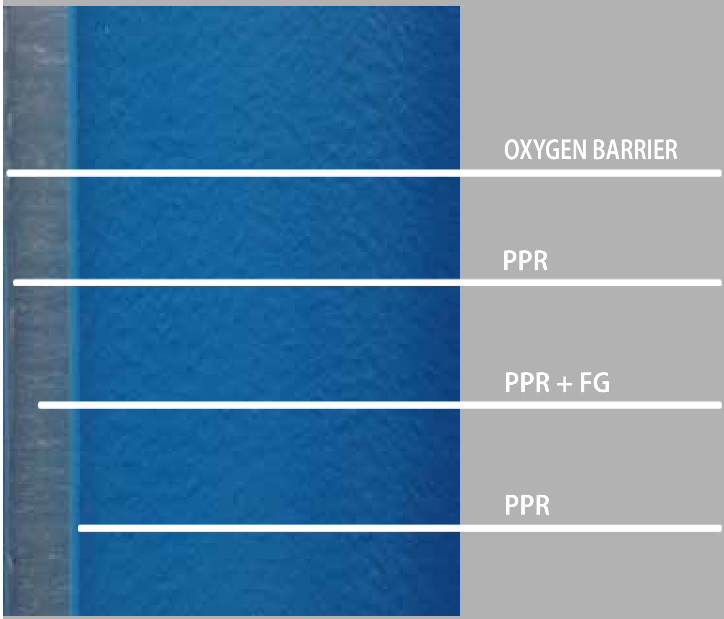





BENEFITS

- Ease of installation and reduced installation time
- Excellent thermal insulation
- Low specific weight
- Low pressure drop
- Excellent weldability thanks to the fittings of the NIRON range
- High resistance to corrosion
- High durability
- Reliable junction
- Resistance to abrasion
- Resistance to stray currents

NIRON®

WHITE BLUE PPR PIPE



OXYGEN BARRIER

Permeation is a multistage process where the permeant molecule (e.g. O_2) collides first with the polymer, then dissolves in the polymer matrix, crosses it and reaches the opposite surface from which it is desorbed and finally moves away migrating in the transported fluid.

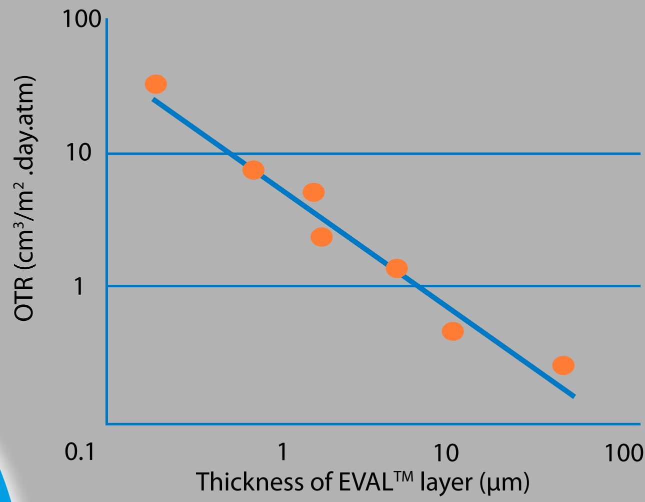
As the oxygen moves through the system, it can lead to corrosion of metallic components, especially in a recirculating system. It is typically a concern in high temperature systems.

Barrier polymers limit the transport of permeant substances through or inside the polymer.

This avoids the problem of water oxygenation and the consequent oxidation and corrosion of metal components that constitute the system. Consequently, the entire system benefits from this situation in terms of duration in time.

EVAL™ layer thickness and OTR

Conditions: EVAL™ EF-F multilayer film 35°C, 0% RH

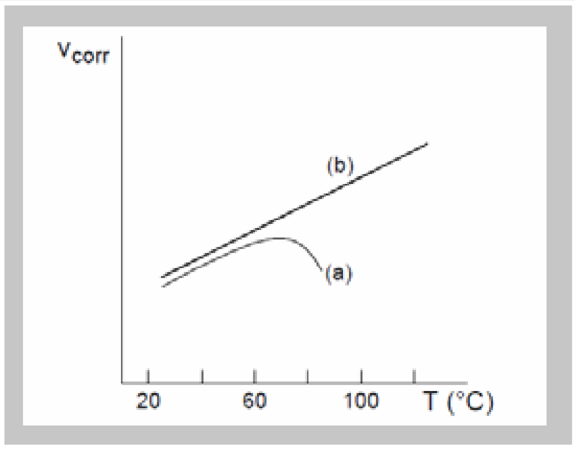


Drinking water	HVACR	Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
	○					○		

We hereby list a group of reference values of the diffusion-limited current density of oxygen for some specific installations/settings. The relationship between current density and speed of generalized corrosion for steel is **1,16 microns / year for 1 mA/m²**.

Approximate values for diffusion-limited current density of oxygen in ventilated mediums

Installation/setting	Diffusion-limited current density of oxygen (mA/m²)
underground installations	5 – 100
offshore installations	50 – 200
water: turbulent flow	200 – 1000
concrete scaffolds: suspended structures	5 – 15
concrete scaffolds: submersed structures	0,2 – 2



INFLUENCE OF TEMPERATURE ON OXYGEN CORROSION RATE: (A) OPEN SYSTEMS, (B) CLOSED SYSTEMS

The rate of oxygen corrosion in the water increases with increasing temperature. It is however necessary to distinguish between closed systems, line (b) and open systems, line (a) as per figure. In open systems, the corrosion rate decreases above about 80° C because of the predominance of the decreasing effect of oxygen solubility.

The concentration of oxygen CO_2, for water in equilibrium with the atmosphere, can be calculated by the following formula:

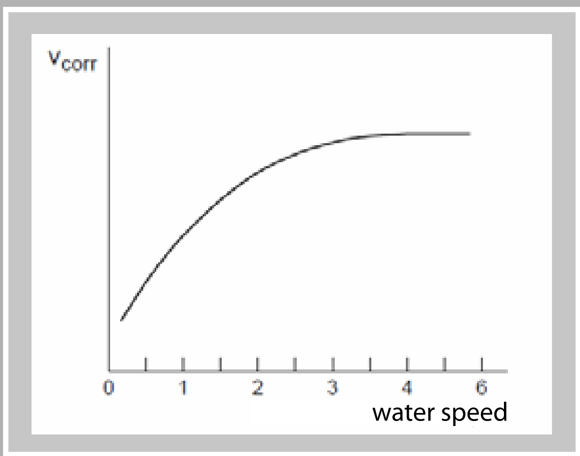
$CO_2 = 14,59 - 0,397 \cdot T + 0,008 \cdot T^2 - 8 \cdot 10^{-5} \cdot T^3 - 6,0443 \cdot C_{NaCl} \cdot (0,0167 - 0,00059 \cdot T + 10^{-5} \cdot T^2)$

where:

CO_2 is the concentration of oxygen in the water in ppm;

CNaCl is the salinity expressed as NaCl in g/l;

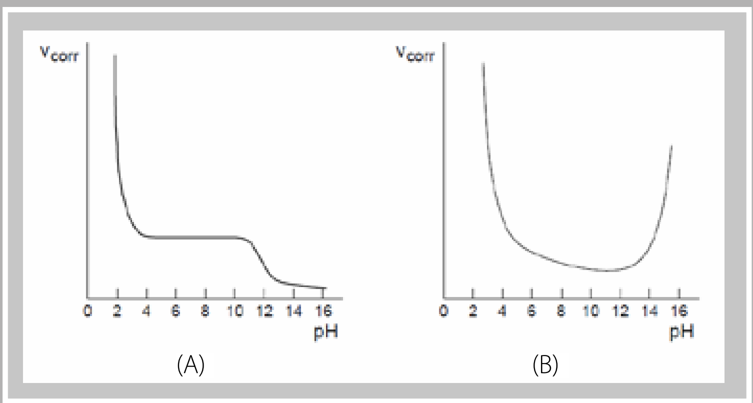
T is the temperature in °C.



INFLUENCE OF WATER SPEED ON OXYGEN CORROSION RATE:

The figure shows the trend of corrosion rate of steel in aerated water according to water speed. The effect of increasing rate of corrosion is due to the greater supply of oxygen on the metal surface. The corrosion rate tends towards an asymptotic value, where the controlling stadium is the oxygen diffusion through a thin layer of corrosion products.

It is well known that by imposing adequate plastic cold deformation, you can increase mechanical properties such as hardness and yield strength of the materials. After these treatments we also assist to a decrease in the strength of the material due to many reasons. At a thermodynamic level, it is likely that there is an influence on the activity of the constituent atoms of metal (even though this is not a very clear aspect), while at kinetic level you can assume the effect of a higher density of lattice defects, as well as of any crystallographic textures and, ultimately, of a greater microstructural inhomogeneities. In case of materials with active-passive behaviour, it is also likely that the protective surface layers are less compact and more defective, therefore less able to perform their shielding action. Mechanical stresses induced by external loads or even related to auto-tension states, further decrease the corrosion resistance of the materials. The combined action of a voltage imposed to the material in a corrosive environment is in many cases much worse than the damage made by the two separate causes. In such circumstances, phenomena such as Stress-Corrosion-Cracking (SCC), Hydrogen-Stress-Cracking and Corrosion-Fatigue can be easily triggered and can induce intense and insidious damage to mechanical or structural components.



INFLUENCE OF PH ON OXYGEN CORROSION RATE:
(A) IRON, (B) ZINC

A generalized corrosion is observed in acidic environments, where the cathodic reaction is the reduction of hydrogen ions to molecular hydrogen gas. The pH is the controlling parameter: the figure shows the influence of pH on corrosion speed for iron and steels in general. Acid corrosion becomes significant for pH lower than 4, increasing exponentially for lower values of pH. With alkaline pH, however, where the presence of OH-ions in solution prevails, the corrosion rate becomes negligible for the formation of a film protective oxide. The behaviour of alkaline pH is different for amphoteric metals such as zinc and aluminum, that in the presence of OH-ions form complex galvanized and aluminized species.

NIRON®
DARK PPR PIPE

PPR PIPING SYSTEM

UV RAY PROTECTION

The influence of ultraviolet (UV) radiation on organic structures is well known. Our skin is not the only organic structure that suffers; even polymers are affected by the oxidation caused by the exposure to sunlight and ultraviolet rays.

The main problem is that there are many parameters that have an influence on photo-oxidation and also several ways to limit its effects.

All types of UV rays can cause a photochemical effect within the polymer structure, that can negatively affect the system performance and cause the degradation of some of its components.

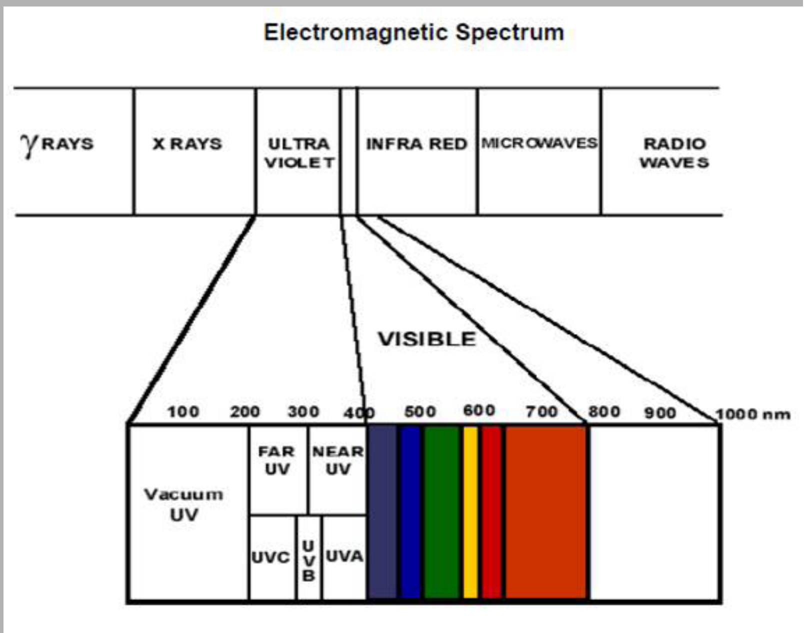
The main visible effects are a chalky appearance and a colour shift.

Photo-oxidation is favored by UV radiation that activates the break of c-c bonds and the formation of hydroperoxides, thermolabile compounds that then trigger a chain reaction.

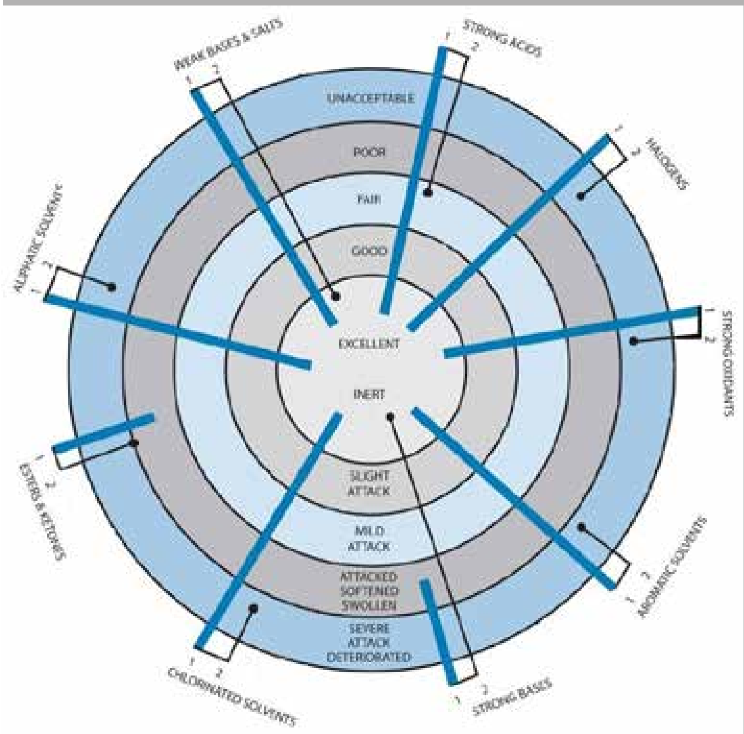
To solve this problem in installations requiring exposure to sunlight (without the need to find other solutions such as insulated piping, insulating products that cover the pipes or a paint that must be periodically replaced), the best option is an HDPE layer, because CARBON BLACK is the material that presents the best and most long-lasting protection against UV rays.

Drinking water	HVACR	Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
	●					●		

- NO PHOTOCHEMICAL ATTACK TO THE POLYMER STRUCTURE
- NO PIGMENTATION CHANGE
- NO CRACKING
- NO THICKNESS REDUCTION DUE TO LIGHT DAMAGE
- TOTALLY COMPATIBLE WITH THE FITTING RANGE



PLATINUM PPR PIPE



PRODUCT PERFORMANCE:

1) PPR + TECHNOPOLYMER BARRIER
2) PPR

TECHNOPOLYMER BARRIER

Thanks to its **BARRIER EFFECT**, NIRON PLATINUM represents the technical solution to the problems caused by the transport of fluids with high percentages of chemical agents at high pressure and temperature within the PPR PIPING SYSTEM range.

These problems cause premature aging of polypropylene and are cancelled thanks to the introduction of an inner piping layer made with a **STATE OF THE ART TECHNOPOLYMER**.

Among the most widely used chemicals, there are solutions for water disinfection, biocidal agents used to prevent the formation of mold and bacteria (in air conditioning systems) and inhibitors that prevent the most common bacterial proliferation in drinking water (such as Legionellosis).

The main mechanisms for the disinfection of drinking water are based on the following chemicals:

- **SODIUM HYPOCHLORITE (NaOCl)**
  NaOCl + H20 => NaOH + HOCl
- **CHLORINE DIOXIDE (ClO_2)**

In the first case, the disinfecting agent is HOCl, while in the second case this function is performed by ClO_2. Both are strong oxidizing agents.

Drinking water	HVACR	Swimming pools	Chemical fluids	Recycled water	Compressed air	Heating	Geothermal applications	Ship building industry
●		●	●			●		

OXIDIZING ACTION

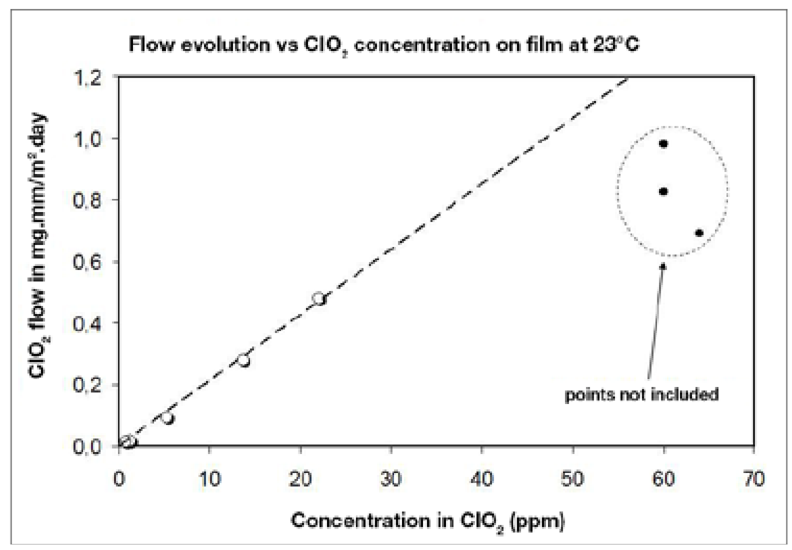
The oxidizing action manifests itself through the early consumption of antioxidants present in the raw material and triggers premature breakage on the molecular ramifications of the material.

As a result, **PREMATURE LONGITUDINAL BREAKAGE** occurs inside the pipe.

CRITICAL KEY FACTORS

The main critical factors are shown in pipes belonging to high classes of SDR (reduced thickness) and pipes installed in systems that are subjected to frequent chlorine-based disinfections, with high working pressure and temperature.

The growing practice of chemical disinfection of water based on chlorinated agents (eg: sodium hypochlorite and chlorine dioxide), used with an increasingly critical combination of frequency/concentration/temperature/pH, requires a different and more accurate design solution ensuring greater durability.



Amount of chlorine deposited on PVDF film (at 23°C) detected considering the presence of ClO_2 in the circuit (ppm) and flow circulating in the system (mg.mm/m^2.day)

The permeation of chemical agents is extremely low thanks to the barrier effect produced by the technopolymer layer.

The mechanical action represented not only by the internal working pressure but also by the effect of any bending that may occur during the installation adds up to this chemical action.

The flexural modulus is a characteristic of the material and indicates the resistance limit of a specific pipe with a given thickness when subjected to bending. When the working conditions of the piping system already stress the material to its limit as regards its resistance to bending, further aggressive action represented by a chemical attack can lead to a real drift in terms of mechanical strength.

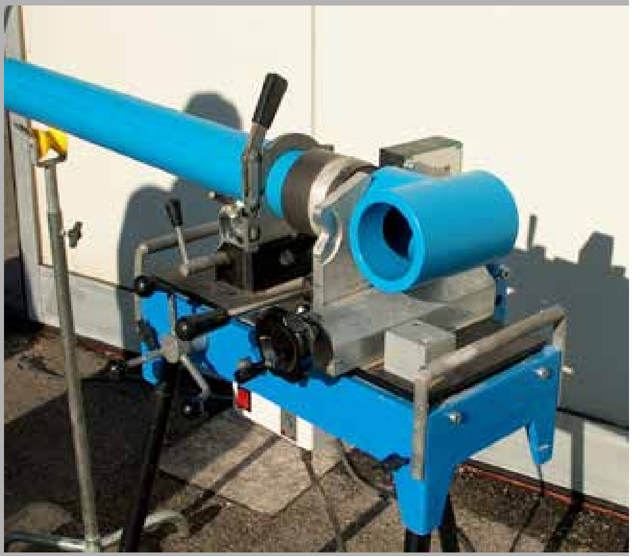
We should also consider the effect due to the action of the transported fluid. In case of high flow rates, this effect may further worsen the situation described so far by adding the erosive factor to the numerous factors already considered.

The solution proposed by NUPIGECO is **NIRON PLATINUM** pipe and its range of fittings. PPR pipe is protected by a PVDF barrier which defends it against attacks by aggressive fluids.

PVDF is a technopolymer characterized by excellent chemical resistance to strong acids and oxidants, high solubility in polar solvents, resistance to UV rays and wide heat applicability range: -40°C/+150°C.

The network conveying aggressive fluids is thus totally secured, both in the linear sections and in the most vulnerable points, i.e. the fittings: bends, elbows and tees.

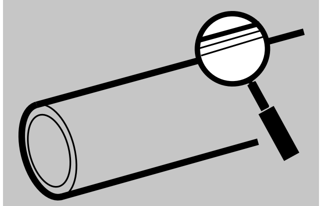
The installation is chemically protected and structurally improved and the product promotes the maintenance of all the advantages of PPR pipes.



PPR
PIPING SYSTEM

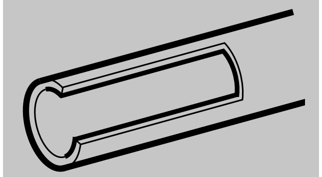
2

TECHNICAL CHARACTERISTICS
PRODUCT AND PRODUCTION PROCESS



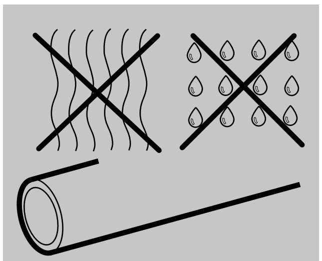
NO CORROSION

PP-R pipes are resistant to any type of water hardness and bear many of the chemical substances with pH values between 1 and 14. PPR is highly resistant to alkalis and many acids, except for some highly concentrated acids.



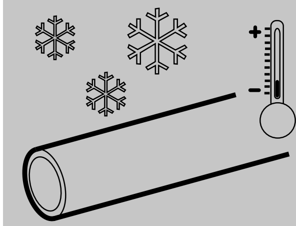
NO SCALING

The inner smoothness of pipes prevents the formation of scale.



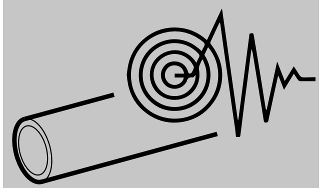
LIMITED HEAT LOSS AND CONDENSATION

Like all plastics, PP-R is a poor heat conductor and is therefore an excellent thermal insulator.



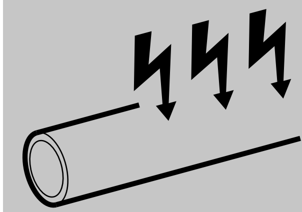
FROST RESISTANCE

The elasticity of PP-R allows the pipe to increase its section when the volume of the fluid changes as the water freezes.



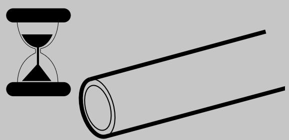
SUITABLE FOR USE IN SEISMIC HAZARD AREAS

This feature is recognized by international boards of experts, as polypropylene is resilient within the structure of a building.



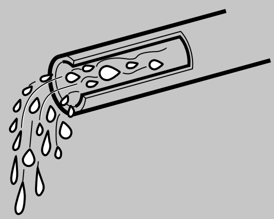
RESISTANCE TO STRAY CURRENTS

Polypropylene is a poor conductor of electricity, so no perforation in the pipe or fitting will ever occur due to stray currents.



DURABILITY

More than 50 years, depending on temperatures and working pressures.

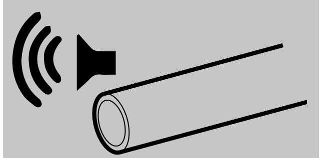


RESISTANCE TO ABRASION

The high abrasion resistance of PPR PIPING SYSTEM allows the passage of water at high velocity without erosion problems.

LIMITED HEAD LOSS

PPR PIPING SYSTEM pipes have limited head loss thanks to its inner smoothness.



LOWER NOISE OF THE SYSTEM

The elasticity and the sound absorption of the material prevent the spread of noise and vibrations due to the passage of water and the water hammer effect.

2.1 BENEFITS

- No corrosion
- No scaling
- Frost resistance
- Limited heat loss and condensation
- Low noise
- Limited head loss
- Resistance to abrasion
- Resistance to stray currents
- Durability
- Lightness

2.1.1 POLYPROPYLENE

The polypropylene used for the **PPR PIPING SYSTEM** by **NUPIGECO** is a special type of Random Copolymer with high molecular weight.

The special structure of its molecules and the appropriate additives used ensure the mechanical resistance and prolonged duration.

PPR is very light and easy to process, therefore the material is effectively used to produce a complete system that allows installation time saving from 30 to 50 %, if compared to the traditional metal systems (steel and copper).

PPR PIPING SYSTEM by **NUPIGECO** is used for the conveyance of drinking water in heating and cooling applications and is also used in the production of refrigeration systems. It is also used for the industrial, agricultural and shipbuilding fields.

The raw material is supplied by international certified suppliers and complies with the most important organoleptic requirements for the transport of drinking water and contact with food fluids.

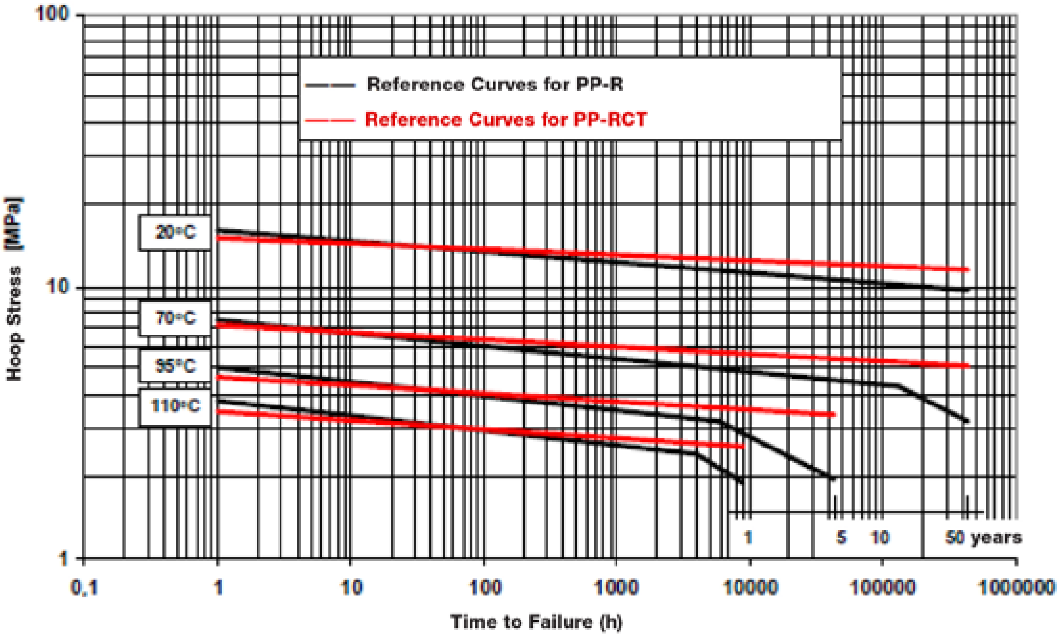
Polypropylene is available in 4 main types of polymer:

TYPE 1	TYPE 2	TYPE 3	TYPE 4
HOMOPOLYMER	BLOCK COPOLYMER	RANDOM COPOLYMER	RANDOM COPOLYMER WITH MODIFIED CRYSTALLINITY
PP-H	PP-B	PP-R	PP-RCT

NUPIGECO uses PP-R and PP-RCT (internally codified as PP-RP) for its NIRON system.

PP-RCT represents the evolution of the 2000s of PP-R. It presents better performance characteristics than its predecessor PP-R.

The regression curve flattened by ensuring lower decay of pressure/temperature performances and the "knee" of the curve disappeared for a more enhanced durability.



The required pipe series for a particular application class is calculated from the design stress and the operating pressure. The outcome of this calculation for operating pressures of 8 bar and 10 bar are presented in table V.

Table V: Comparison of the required pipe series and SDR for PP-R and PP-RCT for the individual application classes

	Operating pressure 8 bar (116 psi)		Operating pressure 10 bar (145 psi)	
	PP-R	PP-RCT	PP-R	PP-RCT
Application class 1 60°C hot water supply	S 3,2 SDR 7,4	S 4 SDR 9	S 2,5 SDR 6	S 3,2 SDR 7,4
Application class 2 70°C hot water supply	S 2,5 SDR 6	S 4 SDR 9	S 2 SDR 5	S 3,2 SDR 7,4
Application class 4 Underfloor heating and low temperature radiators	S 3,2 SDR 7,4	S 4 SDR 9	S 3,2 SDR 7,4	S 3,2 SDR 7,4
Application class 5 High temperature radiators	S 2 SDR 5	S 3,2 SDR 7,4	-	S 2,5 SDR 6

Numerous international certificates ensure high quality standard of the **PPR PIPING SYSTEM** by **NUPIGECO**:

KIWA (Italy)
DVGW (Germany)
AENOR (Spain)
OVGW (Austria)
Certif (Portugal)
CSTBat (France)
ATG (Belgium)
WRAS (UK)
RINA (Italy)
Lloyd Register (UK)
Eurofins (France)

2.1.2 PROPERTIES OF THE MATERIAL

Properties	Test method	Values at 23°C	Unit of measure
Volumic mass	ISO 1183	**0,898**	g/cm³
Yield strength	ISO 527	**23**	N/mm²
Elongation at break	ISO 527	**> 50**	%
Modulus of elasticity	ISO 527	**850**	N/mm²
Melt flow index MFI 190/5	ISO 1133 Procedure 18	**0,5**	g/10 min
Heat conductivity (λ)	DIN 52612	**0,24**	W/mk
Linear thermal expansion coefficient	VDE 0304	**$1,5 \times 10^{-4}$**	K^{-1}
Melting point	DIN 53736b2	**150 - 154**	°C
Impact strength (Charpy) +23°C	ISO 179/1 e A	**no break**	KJ/m²
-30°C	ISO 179/1 e A	**50**	KJ/m²
Volumic strength	IEC 93	**$>10^{15}$**	Ω cm
Dielectric strength	IEC 243/1	**75**	KV/mm
Dielectric loss factor	DIN 53483	**$< 5 \times 10^{-4}$**	
Fire resistance	DIN 4102	**B2**	

2.1.3 CHEMICAL AND THERMAL DISINFECTION

A) CHEMICAL DISINFECTION OF DRINKING WATER

The continuous disinfection with chlorinated drinking water may occur with a concentration of free chlorine up to 0,5 ppm (mg / l).

In Italy, the maximum allowable concentration of free chlorine in water is 0,2 ppm (mg / l).

The maximum temperature of 70° C shall not be exceeded.

The level of parameters is different for each country, for this reason the system must comply with the restrictions relating to drinking water in the country where the pipe will be installed.

Chlorine dioxide as a disinfectant

The use of chlorine dioxide as a disinfectant in drinking water supply is increasing in recent years, as the chemical reactivity (and therefore the effects of the disinfection) is about three times higher in case of free chlorine.

This high oxidation generates potential damage to the **PPR PIPING SYSTEM**.

B) THERMAL DISINFECTION OF THE SYSTEM

The washing temperature is adjusted so that the level of 70° C for a minimum of 3 minutes at all points of the drinking water network is maintained.

It is essential to observe the maximum allowable limits indicated by the regulations in force, as regards temperature and working pressure, that differ according to the application and use of the building where the system is placed.

C) UV TREATMENT FOR THE DISINFECTION OF DRINKING WATER SYSTEMS

The irradiation with ultraviolet light is a valid alternative method for the disinfection of drinking water. The application of ultraviolet light is a method of disinfection which seems to be more effective in the proximity of the point of use.

GENERAL INDICATIONS FOR ALL PLUMBING APPLICATIONS

We hereby list some possible actions aimed at preventing the spread of the bacterium that causes Legionellosis in water supply zones:

- avoid pipes with closed end sections;
- move the recirculation loop (if any) as close as possible to the user;
- periodically increase the water supply temperature to 55° C (more if required by maintenance protocols);
- expose the supply of water to UV rays using special lamps.

The preventive treatments against the bacterium, in air conditioning systems, are the following:

- use of special devices (droplet separator) in cooling towers;
- design of cooling towers so that the air flow can be channeled into the outer air intakes;
- regular cleaning of prevention systems, in order to eliminate the nutrients of the bacterium;
- regular chlorination of the network, according to the standards and parameters of the law.

2.1.4 CERTIFIED QUALITY

We hereby list the reference laws, guidelines and standards for the **PPR PIPING SYSTEM** by **NUPIGECO**:

- GENERAL QUALITY AND DIMENSION REQUIREMENTS

UNI EN ISO 15874 Plastics piping systems for hot and cold water installations -- Polypropylene (PP).

ASTM F2389 Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems.

CSA B137.11 Polypropylene (PP-R) pipe and fittings for pressure applications.

NSF/ANSI Standard 14 Plastics Piping System Components and Related Materials.

DIN 8077 Polypropylene (PP) Pipes - PP-H, PP-B, Pp-R, PP-RCT – Dimensions.

DIN 8078 Polypropylene (PP) Pipes - PP-H, PP-B, Pp-R, PP-RCT – General quality requirements and testing.

DVGW Working sheets.

- HYGIENIC LAWS AND SPECIFICATIONS

W270 (Germany) [Increase of Microorganisms on materials. Used for potable water application-Test and Evaluation].

BS 6920 British Standard Suitability Of Non-Metallic Products For Use In Contact With Water Intended For Human Consumption With Regard To Their Effect On The Quality Of The Water.

ACS (Attestation de Conformité Sanitaire)

Hydrocheck (Belgaqua)

D.M. 174 of 16.04.04 (Italy)

NSF/ANSI Standard 61 Drinking Water System Components - Health Effects.

- INSTALLATION STANDARDS

DIN 2000 Guidelines For Drawing Up Requirements For The Design, Construction, Operation And Maintenance Of Public Drinking Water Supply System.

EN 806 Specifications For Installations Inside Buildings Conveying Water For Human Consumption.

DIN 1988 Codes of practice for drinking water installations - DVGW code of practice.

DIN 4109 Standard for the elimination of noise in the field of structural engineering.

DIN 16962 Pipe Joints And Elements For Polypropylene (Pp) - Pressure Pipelines.

DVS 2207 Welding of thermoplastic materials.

DVS 2208 Welding machines and devices for thermoplastic materials.

DIN 18381 German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - Installation of gas, water and drainage pipework inside buildings.

DIN 16928 Pipes of Thermoplastic Materials; Pipe Joints, Elements for Pipes, Laying; General Directions.

CERTIFIED QUALITY

The quality of the PPR PIPING SYSTEM by NUPIGECO is guaranteed by numerous national and international independent bodies.

2.1.5 CONTROL SYSTEM

The production of pipes and fittings requires the supervision, regulation and control of all the working operations. All results are recorded and documented.

OUR STANDARD INCLUDES:

- acceptance testing of raw materials and incoming goods;
- process control;
- inspection and testing of products;
- final inspection and sample tests on the production batches.

This procedure is required by the standard that regulates the Quality Management System (UNI EN ISO 9001) and the relevant protocols for the quality control of piping systems for the transport of water inside buildings (UNI EN ISO 15874, ASTM F2389, etc.).

INTERNAL CONTROL

Skilled employees ensure that all assessments are carried out according to the appropriate regulations and fulfill all technical arrangements in accordance with the quality policy.

All internal quality controls are documented, recorded and stored in accordance with the provisions of law.

2.1.6 QUALITY ASSURANCE

ACCEPTANCE OF INCOMING GOODS

All incoming goods are subject to specific tests that guarantee that incoming products conform to the specified requirements.

INSPECTION AND TEST

The quality plan adopted by NUPIGECO requires that tests and inspections are carried out before and during the production process.

During the production phase, the quality plan establishes that products pass the following tests:

- dimensional check;
- surface check;
- marking check;
- control of process parameters.

The samples are collected and sent to the quality department that performs quality checks and performance testing on the products and submits them to various degrees and types of stress (pressure, temperature, oxidation, etc.).

FINAL INSPECTION AND TESTING

The quality plan adopted by NUPIGECO requires that the inspections and tests are carried out on the entire production cycle.

All test results are documented in the test report and the certificate 3.1 (available on request).

Final tests include:

- internal pressure test at 95° C (time and pressure are specified in the reference standard);
- cold impact test;
- oxidation induction time;
- melt flow index;
- homogeneity test with polarized light microscopy;
- dimensional checks;
- elongation test with dynamometer;
- tensile test (> 23 N/mm^2) with dynamometer.

After the final tests, more tests are carried out on some batches:

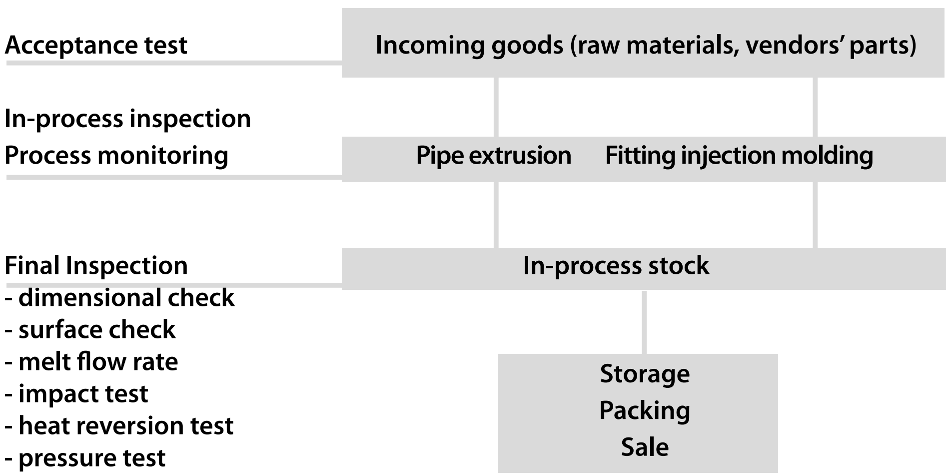
- thermal cycle: pipes and fittings are subjected to temperature cycles lasting 15 minutes at 95° C and 15 minutes at 20° C with a pressure of 10 bar for a total of 5.000 cycles;
- oxidation induction time: determining the percentage of antioxidants in the product after the extrusion process;
- thermal stability at 110° C for 8.760 hours (= 1 year).

STORAGE/PACKING/SHIPPING

Upon positive test results, the products are suitably packaged and stored in suitable warehouses.

The internal procedure regarding the method of packing, storage and shipping of products is represented by the following diagram.

INTERNAL CONTROL - SYSTEM CONTROL



EXTERNAL AUDIT

NUPIGECO submits its management and production system to external audits performed by third party certification bodies.

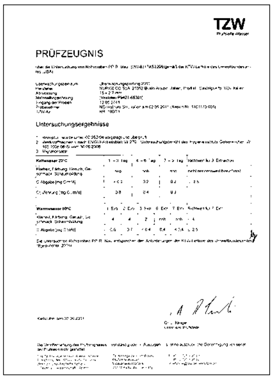
The external audit consists of tests carried out at given intervals.

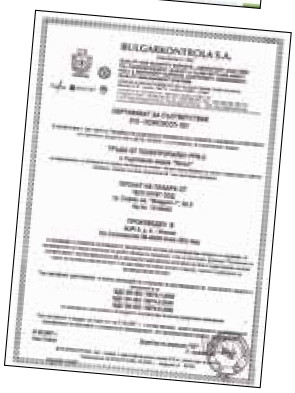
Audit frequency depends on the procedure established by the specific standard and by each certification body.

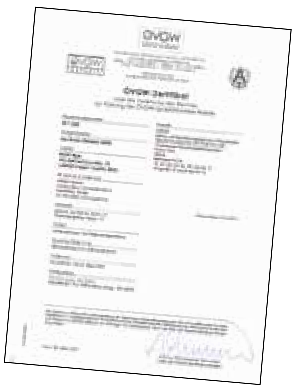
The external supervision also provides:

- verification of the quality system;
- calibration of test equipment;
- hygiene and toxicity tests.

The results are confirmed by test certificates obtained by NUPIGECO.

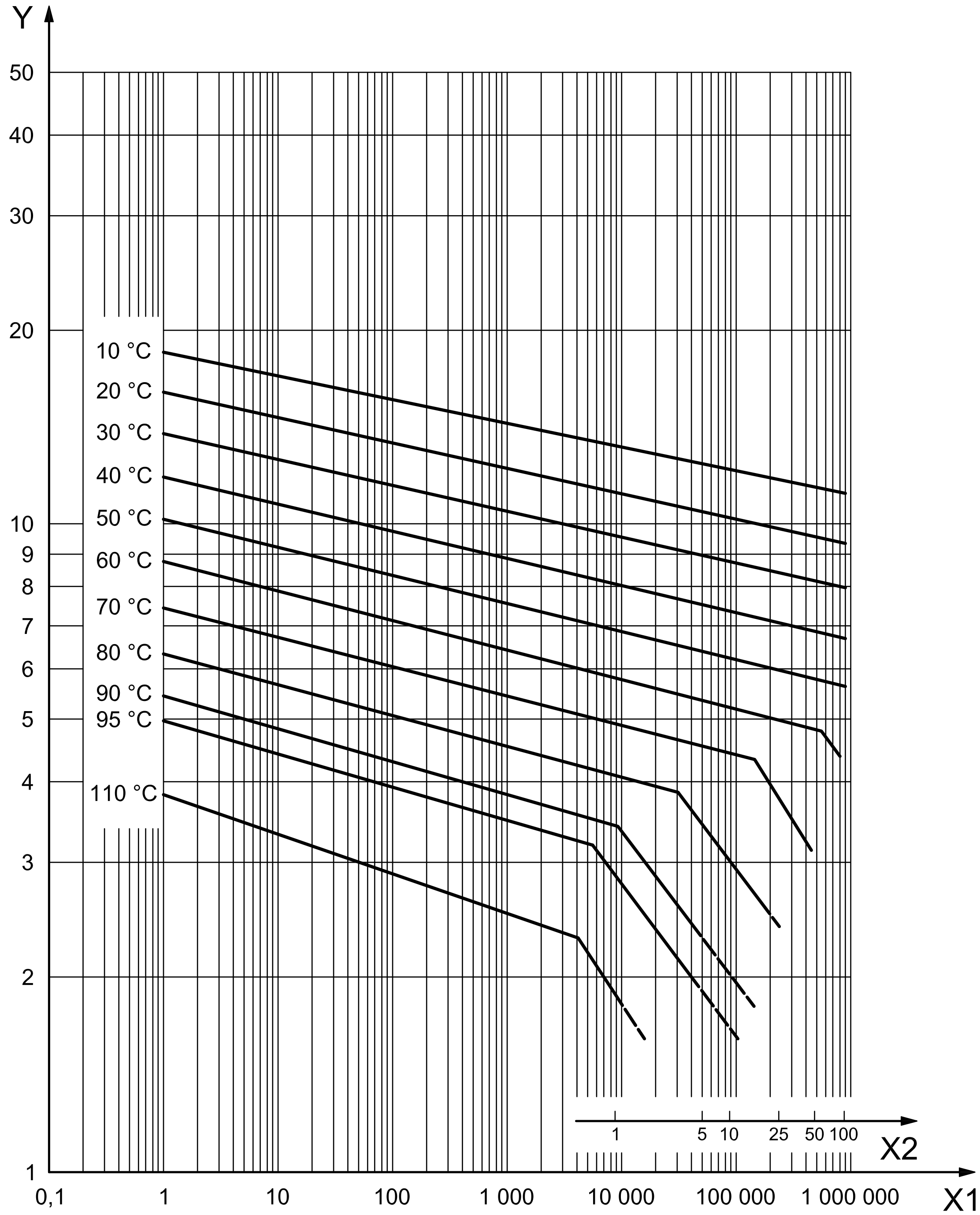






REGRESSION CURVES FOR PP-R

UNI EN ISO 15874-2 (E)

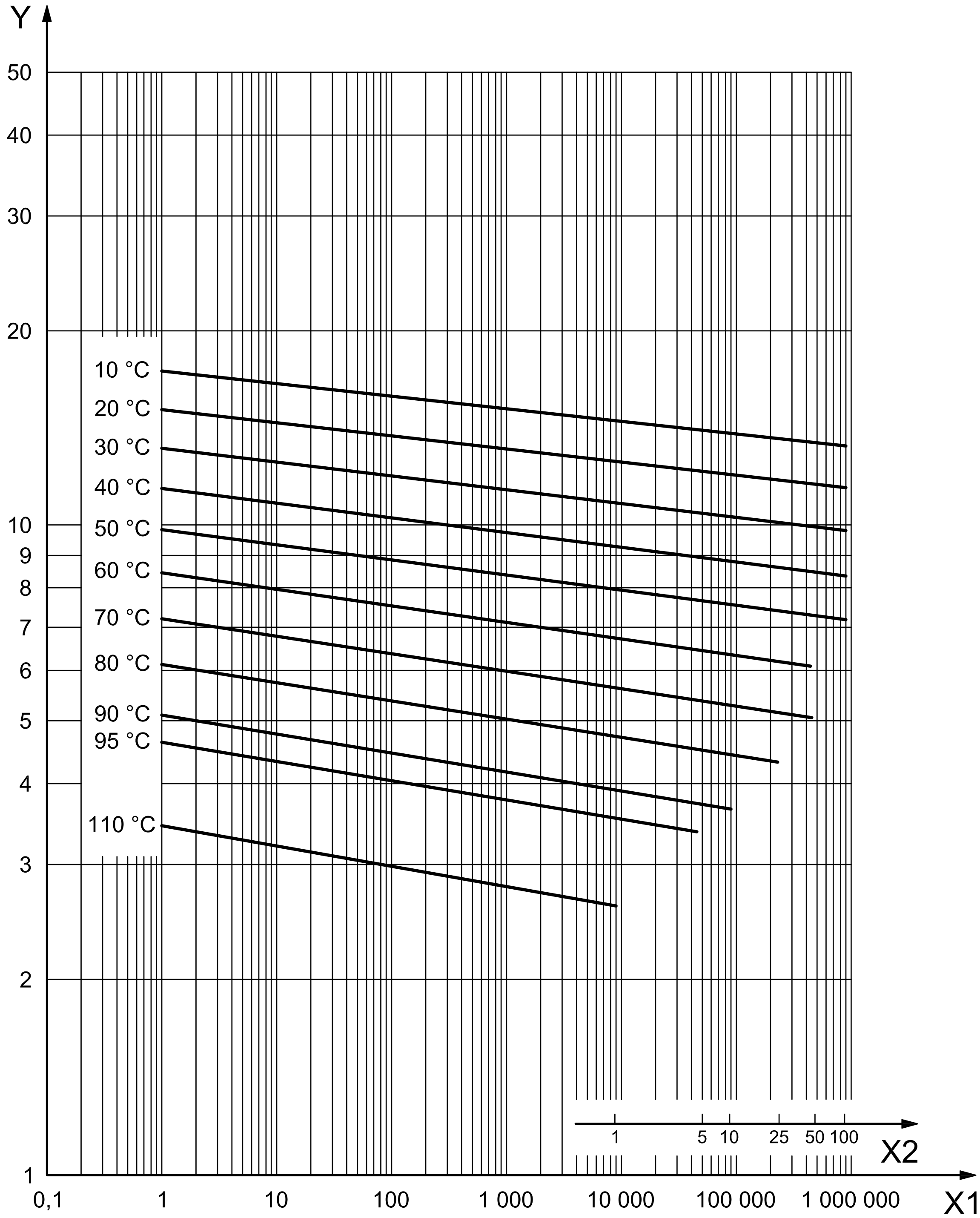


Key
X1 time, t_1, to fracture, in hours

Key
X1 time, t_1, to fracture, in hours
X2 time, t_2, to fracture, in years
Y hoop stress, σ, in megapascal

REGRESSION CURVES FOR PP-RCT

UNI EN ISO 15874-2 (E)



Key

X1 time, t_1, to fracture, in hours

X2 time, t_2, to fracture, in years

Y hoop stress, σ, in megapascal

DIN 8077-09 - TABLE 9 ALLOWABLE OPERATING PRESSURES FOR PPR PIPES CONVEYING WATER						
Safety factor (SF) = 1,25						
T°	Years of service	S 2,5 SDR 6	S 3,2 SDR 7,4	S 4 SDR 9	S 5 SDR 11	S 8 SDR 17
		ALLOWABLE OPERATING PRESSURE (bar)-(psi)				
10	1	42,10	33,40	26,50	21,10	13,30
	5	39,70	31,50	25,00	19,80	12,50
	10	38,60	30,70	24,40	19,30	12,20
	25	37,40	29,70	23,60	18,70	11,80
	50	36,40	28,90	23,00	18,20	11,50
	100	35,50	28,20	22,40	17,80	11,20
20	1	35,90	28,50	22,60	18,00	11,30
	5	33,70	26,80	21,30	16,90	10,60
	10	32,80	26,10	20,70	16,40	10,40
	25	31,70	25,20	20,00	15,90	10,00
	50	30,90	24,50	19,50	15,40	9,70
	100	30,10	23,90	18,90	15,00	9,50
30	1	30,50	24,20	19,20	15,30	9,60
	5	28,60	22,70	18,00	14,30	9,00
	10	27,80	22,10	17,50	13,90	8,80
	25	26,80	21,30	16,90	13,40	8,40
	50	26,10	20,70	16,40	13,00	8,20
	100	25,40	20,10	16,00	12,70	8,00
40	1	25,90	20,60	16,30	13,00	8,20
	5	24,20	19,20	15,30	12,10	7,60
	10	23,50	18,70	14,80	11,80	7,40
	25	22,60	18,00	14,30	11,30	7,10
	50	22,00	17,40	13,90	11,00	6,90
	100	21,40	16,90	13,50	10,70	6,70
50	1	21,90	17,40	13,80	11,00	6,90
	5	20,40	16,20	12,90	10,20	6,40
	10	19,80	15,70	12,50	9,90	6,20
	25	19,00	15,10	12,00	9,50	6,00
	50	18,50	14,70	11,60	9,20	5,80
	100	17,90	14,20	11,30	9,00	5,60
60	1	18,50	14,70	11,60	9,20	5,80
	5	17,20	13,60	10,80	8,60	5,40
	10	16,60	13,20	10,50	8,30	5,20
	25	16,00	12,70	10,10	8,00	5,00
	50	15,50	12,30	9,70	7,70	4,90
70	1	15,50	12,30	9,80	7,80	4,90
	5	14,40	11,40	9,10	7,20	4,50
	10	13,90	11,10	8,80	7,00	4,40
	25	12,10	9,60	7,60	6,00	3,80
	50	10,20	8,10	6,40	5,10	3,20
80	1	13,00	10,30	8,20	6,50	4,10
	5	11,50	9,10	7,20	5,70	3,60
	10	9,70	7,70	6,10	4,80	3,00
	25	7,80	6,20	4,90	3,90	2,40
95	1	9,20	7,30	5,80	4,60	2,90
	5	6,20	4,90	3,90	3,10	1,90

DIN 8077-09 - TABLE 11 ALLOWABLE OPERATING PRESSURES FOR PP-RP PIPES CONVEYING WATER				
Safety factor (SF) = 1,25				
T°	Years of service	S 3,2 SDR 7,4	S 4 SDR 9	S 8 SDR 17
		ALLOWABLE OPERATING PRESSURE (bar)-(psi)		
10	1	36,20	28,80	14,40
	5	35,10	27,90	14,00
	10	34,70	27,50	13,80
	25	34,10	27,10	13,50
	50	33,60	26,70	13,40
	100	33,20	26,30	13,20
20	1	31,50	25,00	12,50
	5	30,50	24,20	12,10
	10	30,10	23,90	12,00
	25	29,60	23,50	11,70
	50	29,20	23,10	11,60
	100	28,80	22,80	11,40
30	1	27,30	21,70	10,80
	5	26,40	20,90	10,50
	10	26,00	20,60	10,30
	25	25,50	20,20	10,10
	50	25,10	19,90	10,00
	100	24,80	19,70	9,80
40	1	23,50	18,60	9,30
	5	22,60	18,00	9,00
	10	22,30	17,70	8,80
	25	21,80	17,30	8,70
	50	21,50	17,10	8,50
	100	21,20	16,80	8,40
50	1	20,10	15,90	8,00
	5	19,30	15,30	7,70
	10	19,00	15,10	7,50
	25	18,60	14,70	7,40
	50	18,30	14,50	7,20
	100	18,00	14,30	7,10
60	1	17,00	13,50	6,70
	5	16,30	13,00	6,50
	10	16,00	12,70	6,40
	25	15,70	12,40	6,20
	50	15,40	12,20	6,10
70	1	14,30	11,30	5,70
	5	13,70	10,90	5,40
	10	13,50	10,70	5,30
	25	13,10	10,40	5,20
	50	12,90	10,20	5,10
80	1	11,90	9,50	4,70
	5	11,40	9,00	4,50
	10	11,20	8,90	4,40
	25	10,90	8,60	4,30
95	1	8,90	7,10	3,50
	5	8,50	6,70	3,30
	10)[a]	(8,30)	(6,60)	(3,30)

[a] The values between parentheses apply in cases where it can be demonstrated that the test was carried out for more than a year at 110°C.

DIN 8077-TABLE 10 ALLOWABLE OPERATING PRESSURES FOR PPR PIPES CONVEYING WATER						
		Safety factor (SF) = 1,50				
T°	Years of service	S 2,5 SDR 6	S 3,2 SDR 7,4	S 4 SDR 9	S 5 SDR 11	S 8 SDR 17
		ALLOWABLE OPERATING PRESSURE (bar)-(psi)				
10	1	35,10	27,80	22,10	17,50	11,10
	5	33,00	26,20	20,80	16,50	10,40
	10	32,20	25,60	20,30	16,10	10,10
	25	31,10	24,70	19,60	15,60	9,80
	50	30,30	24,10	19,10	15,20	9,60
	100	29,60	23,50	18,60	14,80	9,30
20	1	29,90	23,70	18,80	15,00	9,40
	5	28,10	22,30	17,70	14,10	8,90
	10	27,40	21,70	17,20	13,70	8,60
	25	26,40	21,00	16,60	13,20	8,30
	50	25,70	20,40	16,20	12,90	8,10
	100	25,00	19,90	15,80	12,50	7,90
30	1	25,40	20,20	16,00	12,70	8,00
	5	23,80	18,90	15,00	11,90	7,50
	10	23,20	18,40	14,60	11,60	7,30
	25	22,30	17,70	14,10	11,20	7,00
	50	21,70	17,20	13,70	10,90	6,80
	100	21,10	16,80	13,30	10,60	6,60
40	1	21,60	17,10	13,60	10,80	6,80
	5	20,20	16,00	12,70	10,10	6,30
	10	19,60	15,50	12,30	9,80	6,20
	25	18,80	15,00	11,90	9,40	5,90
	50	18,30	14,50	11,50	9,20	5,80
	100	17,80	14,10	11,20	8,90	5,60
50	1	18,20	14,50	11,50	9,10	5,70
	5	17,00	13,50	10,70	8,50	5,30
	10	16,50	13,10	10,40	8,20	5,20
	25	15,90	12,60	10,00	7,90	5,00
	50	15,40	12,20	9,70	7,70	4,80
	100	14,90	11,80	9,40	7,50	4,70
60	1	15,40	12,20	9,70	7,70	4,80
	5	14,30	11,30	9,00	7,10	4,50
	10	13,90	11,00	8,70	6,90	4,30
	25	13,30	10,50	8,40	6,60	4,20
	50	12,90	10,20	8,10	6,40	4,00
70	1	12,90	10,30	8,10	6,50	4,10
	5	12,00	9,50	7,50	6,00	3,80
	10	11,60	9,20	7,30	5,80	3,60
	25	10,00	8,00	6,30	5,00	3,10
	50	8,50	6,70	5,30	4,20	2,60
80	1	10,80	8,60	6,80	5,40	3,40
	5	9,60	7,60	6,00	4,80	3,00
	10	8,10	6,40	5,10	4,00	2,50
	25	6,50	5,10	4,10	3,20	2,00
95	1	7,60	6,10	4,80	3,80	2,40
	5	5,20	4,10	3,20	2,60	1,60

DIN 8077-TABLE 12 ALLOWABLE OPERATING PRESSURES FOR PP-RP PIPES CONVEYING WATER				
Safety factor (SF) = 1,50				
T°	Years of service	S 3,2 SDR 7,4	S 4 SDR 9	S 8 SDR 17
		ALLOWABLE OPERATING PRESSURE (bar)-(psi)		
10	1	30,20	24,00	12,00
	5	29,30	23,20	11,60
	10	28,90	22,90	11,50
	25	28,40	22,50	11,30
	50	28,00	22,20	11,10
	100	27,60	21,90	11,00
20	1	26,30	20,90	10,40
	5	25,40	20,20	10,10
	10	25,10	19,90	10,00
	25	24,60	19,60	9,80
	50	24,30	19,30	9,60
	100	24,00	19,00	9,50
30	1	22,70	18,10	9,00
	5	22,00	17,40	8,70
	10	21,70	17,20	8,60
	25	21,20	16,90	8,40
	50	20,90	16,60	8,30
	100	20,60	16,40	8,20
40	1	19,60	15,50	7,80
	5	18,90	15,00	7,50
	10	18,60	14,70	7,40
	25	18,20	14,40	7,20
	50	17,90	14,20	7,10
	100	17,60	14,00	7,00
50	1	16,70	13,30	6,60
	5	16,10	12,80	6,40
	10	15,80	12,60	6,30
	25	15,50	12,30	6,10
	50	15,20	12,10	6,00
	100	15,00	11,90	5,90
60	1	14,20	11,20	5,60
	5	13,60	10,80	5,40
	10	13,40	10,60	5,30
	25	13,10	10,40	5,20
	50	12,80	10,20	5,10
70	1	11,90	9,40	4,70
	5	11,40	9,10	4,50
	10	11,20	8,90	4,40
	25	10,90	8,70	4,30
	50	10,70	8,50	4,20
80	1	9,90	7,90	3,90
	5	9,50	7,50	3,70
	10	9,30	7,40	3,70
	25	9,10	7,20	3,60
95	1	7,40	5,90	2,90
	5	7,10	5,60	2,80
	10)[a]	(6,90)	(5,50)	(2,70)

[a] The values between parentheses apply in cases where it can be demonstrated that the test was carried out for more than a year at 110°C.

COMBUSTION VALUES FOR PPR PIPING SYSTEM PIPES EXPRESSED IN [KWH/METER] AND [KJ/METER]

OD		SDR 6 - S 2,5 - FULL PIPE		SDR 7,4 - S 3,2 - FULL PIPE		SDR 7,4 - S 3,2 - MULTILAYER		SDR 9 - S 4 - FULL PIPE	
In	mm	kWh/m	kJ/m	kWh/m	kJ/m	kWh/m	kJ/m	kWh/m	kJ/m
	16	1,41	5.060,00						
1/2"	20	2,20	7.912,00			2,05	7.360,00		
3/4"	25	3,40	12.236,00	2,94	10.580,00	3,20	11.500,00		
1"	32	5,56	19.964,00	4,74	17.020,00	5,12	18.400,00	3,94	14.167,12
1 1/4"	40	8,59	30.866,00	7,30	26.220,00	7,81	28.060,00	6,19	22.233,80
1 1/2"	50	13,31	47.840,00	11,26	40.480,00	12,03	43.240,00	9,50	34.128,28
2"	63	20,74	74.520,00	17,79	63.940,00	19,07	68.540,00	14,97	53.810,22
2 1/2"	75	29,31	105.340,00	25,47	91.540,00	27,01	97.060,00	21,16	76.050,48
3"	90	42,24	151.800,00	36,22	130.180,00	38,53	138.460,00	30,52	109.690,11
4"	110	62,98	226.320,00	54,40	195.500,00	57,22	205.620,00	45,36	163.014,26
	125	80,64	289.800,00	69,25	248.860,00	73,60	264.500,00	58,67	210.840,40
6"	160			112,51	404.340,00	119,17	428.260,00	95,49	343.165,06
8"	200			180,48	648.600,00	192,06	690.230,00	148,10	532.234,45
	250			282,88	1.016.600,00	300,42	1.079.620,00	229,85	826.032,43
10"	315					464,64	1.669.800,00	363,05	1.304.703,58
	355					588,80	2.116.000,00	460,15	1.653.671,74
16"	400							582,44	2.093.138,03
	450								
20"	500								
	560								
24"	630								

OD		SDR 9 - S 4 - MULTILAYER		SDR 11 - S 5 - FULL PIPE		SDR 11 - S 5 - MULTILAYER		SDR 17 - S 8 - MULTILAYER	
In	mm	kWh/m	kJ/m	kWh/m	kJ/m	kWh/m	kJ/m	kWh/m	kJ/m
	16								
1/2"	20								
3/4"	25								
1"	32	4,20	15.088,00	3,33	11.960,00	3,58	12.880,00		
1 1/4"	40	6,54	23506,00	5,12	18.400,00	5,50	19.780,00		
1 1/2"	50	10,12	36.386,00	8,06	28.980,00	8,58	30.820,00		
2"	63	16,14	58.006,00	12,67	45.540,00	13,31	47.840,00		
2 1/2"	75	22,67	81.466,00	17,54	63.020,00	18,43	66.240,00		
3"	90	32,64	117.300,00	25,47	91.540,00	26,62	95.680,00		
4"	110	48,50	174.294,00	37,12	133.400,00	39,68	142.600,00		
	125	62,54	224.756,00	49,15	176.640,00	51,46	184.920,00		
6"	160	102,23	367.402,00	79,62	286.120,00	83,20	299.000,00	55,42	199.180,00
8"	200	159,86	574.494,00	124,93	448.960,00	130,69	469.660,00	152,32	547.400,00
	250	248,61	893.458,00	192,00	690.000,00	201,98	725.880,00	189,44	680.800,00
10"	315	395,23	1.420.342,00	314,88	1.131.600,00	321,02	1.153.680,00	213,76	768.200,00
	355	501,80	1.803.338,00	399,36	1.435.200,00	399,36	1.435.200,00	271,36	975.200,00
16"	400	582,44	2.093.138,03	506,88	1.821.600,00	517,25	1.858.860,00	343,04	1.232.800,00
	450			641,28	2.304.600,00	641,28	2.304.600,00	433,92	1.559.400,00
20"	500							536,32	1.927.400,00
	560							672,00	2.415.000,00
24"	630							851,20	3.059.000,00

Test methods used to evaluate the fire behaviour differ according to the specific application. Our tests show that the raw material used to produce the **PPR PIPING SYSTEM** by **NUPIGECO** (blue and green versions) without flame retardants are classified as B2 MATERIALS, which means ***NORMALLY FLAMMABLE***.

According to European Standard EN 13501 - Sheet 1 the worst fire behaviour class is class E.

At temperatures above 300° C, the polypropylene melts and starts decomposing and developing flammable gases at temperatures above 350° C.

According to ASTM D 1929 Standard, the self ignition temperature is approximately 360°C and the flash ignition temperature is 330°C.

The main products of complete combustion found in our raw material are carbon, carbon dioxide and water.

Other secondary products are carbon monoxide and hydrocarbons with low molecular weight.

The toxicity of the combustion gases depends on the content of carbon monoxide. The product of thermal degradation is less toxic than the one released by other types of combustion such as that of wood, in the same circumstances.

The oxygen index of our PPR without flame retardant is 18% (test carried out according to Standard ASTM D 2683 / ISO 4589).

The fumes are not particularly corrosive.

The lower heating power of the material is about 46.000 kJ/kg or 12,8 kWh/kg, similar to the value of fuel oil.

The tables indicating the combustion values on page 66 are based on the lower heating power of the material (in kWh/kg or kJ/kg) and the mass of the pipe (in kg/m).

PPR
PIPING
SYSTEM

3

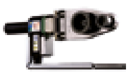
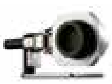
JOINING PROCEDURES

3.1 WELDING EQUIPMENT

Suitable equipment complying with guidelines DVS2207 shall be used for a fast and efficient installation of **PPR PIPING SYSTEM**:

1) Welder 800 W - 220V AC – 50 Hz model **00NSBEP** supplied in a special carrying case, complete with die pairs required for the welding of diameters 20 - 25 - 32. The welder is equipped with an automatic thermostat to maintain the temperature of the die pair constant at 260 ± 10 ° C and is available with a voltage of 110V or 48V upon request.

2) Welder on wheels (1400 W - 220V AC - 50 Hz) model **00STL125** is supplied on pallet complete with die pairs from diameter 25 to diameter 125 and pipe support.

Equipment	Item code	Power supply	16	20	25	32	40	50	63	75	90	110	125	160	200	250	315	355	400	450	500	560	630
	**00NSBEP**	220W 800W	X	X	X	X	Die pairs included: ø 20mm - 25mm - 32mm																
	00NSBEP63	220W 800W	X	X	X	X	X	X	X	Die pairs from ø 20mm to ø 63mm included													
	**00NPCCE**	800W	X	X	X	X	X	X	X	Die pairs NOT included													
	**00NPCCE125**	1400W	X	X	X	X	X	X	X	X	X	X	X	Die pairs NOT included									
	**00STL125**	1400W			X	X	X	X	X	X	X	X	X	Die pairs included									
	**00S10160**						X	X	X	X	X	X	X	X									
	**00S10250**								X	X	X	X	X	X	X	X							
	**00S10315**								X	X	X	X	X	X	X	X	X						
	**00E8500**	230W		X	X	X	X	X	X	X	X	X	X	X	X	X	X						
	**00E9001**	230V		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

3) The **multi-function electrofusion welding machine** for electrofusion fittings is available in two models:
- with automatic insertion of the welding parameters, i.e. provided with a scanner to read the barcodes on the fitting to be welded (model **00E9001**);
- with manual input of welding parameters (model **00E8500**).

Both welding machines are equipped with a power cable 3,5 m long.
The length of the connecting cables between the machine and the fitting is 3m.
The total weight is 15kg.

4) The **welding machines for butt fusion fittings** differ according to the diameter to be welded:
   a. from Ø40mm to Ø160mm (model **00E10160**);
   b. from Ø63mm to Ø250mm (model **00E10250**);
   c. from Ø63mm to Ø315mm (model **00E10315**).

Each unit is supplied complete with:
- basic machine;
- heating plate;
- hydraulic control unit;
- electric milling machine;
- hydraulic hoses;
- adapters.

Technical data		
Voltage	230V - Single phase 50/60 Hz (TE)	230V - Single phase 50/60 Hz (TE)
Working temperature		TFE: 260°C (±1°) TE: 180 ÷ 290°C
Ambient temperature		-5 ÷ +40°C
Material		HDPE, PP, PP-R, PB, PVDF

Models	ø Max diameter	Power supply	Dimensions (W x D x H)	Weight
00NSBEP63	63 mm	500 W	115 x 50 x 320 mm	1,44 Kg
00NPCCE	63 mm	800 W	175 x 50 x 360 mm	1,82 Kg
00NPCCE125	125 mm	1400 W	115 x 50 x 396 mm	3,16 Kg

Technical Data		
Working range	25 ÷ 125 mm	
Voltage	110V	230V
	Monophase - 50/60 Hz	
Total absorbed power	1400W	1400W
Working temperature	180 ÷ 280°C	
Room temperature range	-5°C ÷ +40°C	
Time to reach welding temperature	~ 10 min.	
Materials	PEAD, PP, PP-R, PB, PVDF	

Dimensions (W x D x H) and Weight	
Machine	1080 x 840 x 580 mm
Carrying case	1500 x 800 x 1300 mm
Weight	100 kg

3.2 POLYFUSION WELDING

3.2.1 WARNINGS AND PRELIMINARY RECOMMENDATIONS

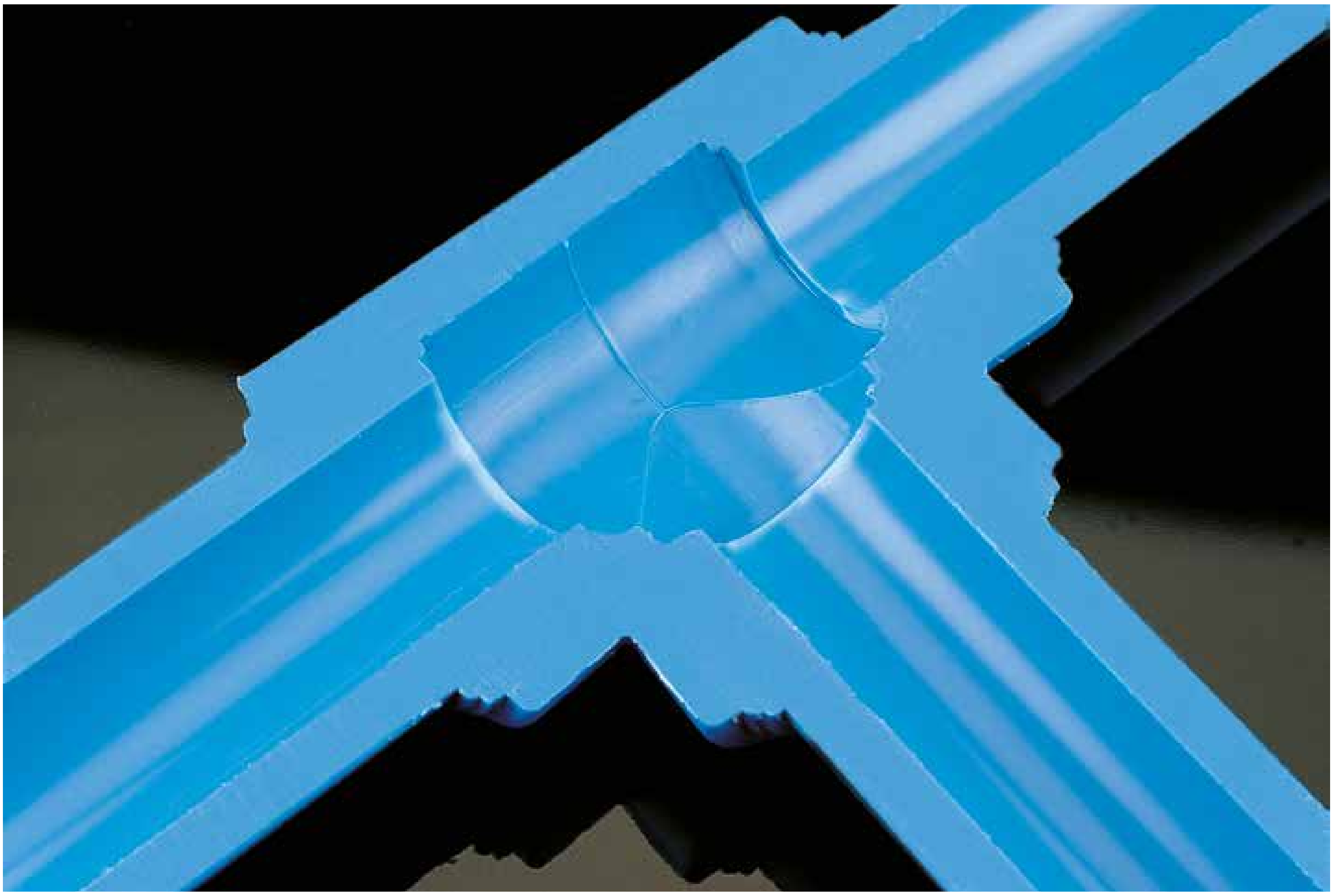
POLYFUSION welding is one of the most widely used junction techniques for the installation of PPR systems. There are just a few and simple steps necessary to complete it but they need the greatest attention.

Welding equipment check

It is necessary to evaluate the efficiency of the equipment and tools to be used.

In particular you should carry out the following operations:

- check the functioning of the thermostat by measuring the temperature on the surface of the die pairs with an appropriate contact thermometer (260° C);
- if you are using a polyfusion welder, check the functioning of the clamps and the handling system of the welding machine so as to ensure the proper alignment of the parts to be welded;
- check the integrity of the non-stick coating of the die pairs.



If a perfect polyfusion welding of the **PPR PIPING SYSTEM** by **NUPIGECO** has been carried out, the section of the junction does not show any difference of material between the pipe and the fitting, proving correct molecular fusion.

3.2.2 POLYFUSION WELDING: FITTINGS

Assemble the die pairs on the cold plate and connect the welder to the power network.

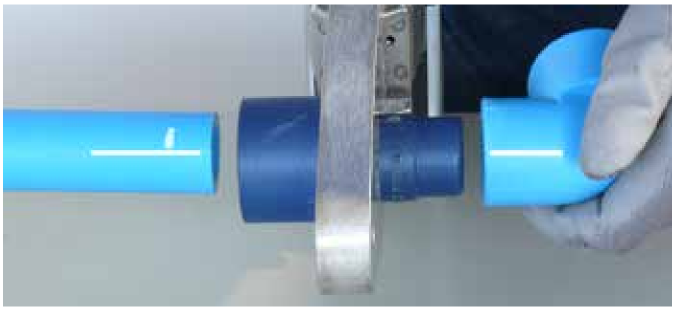
Wait for the sound signal (see the user's manual of the welder) that informs that the required temperature has been reached.

Cut the pipe perpendicularly to its axis using the suitable pipe cutter.

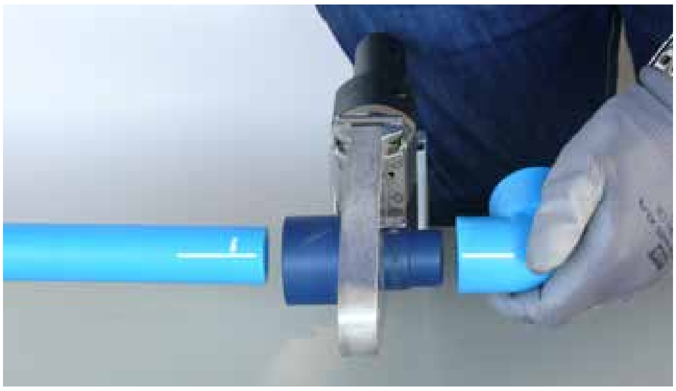
Inside the case that contains the welder you will find a sheet that shows the welding parameters (diameter, pipe insertion depth, heating time, fusion time and time prior to testing).

Mark the insertion length on the pipe.

Mark a longitudinal sign as a reference on the external surfaces of the pipe and fitting to avoid turning the components to be welded while performing the welding procedure (do not cut the surface of the pipe and fitting).

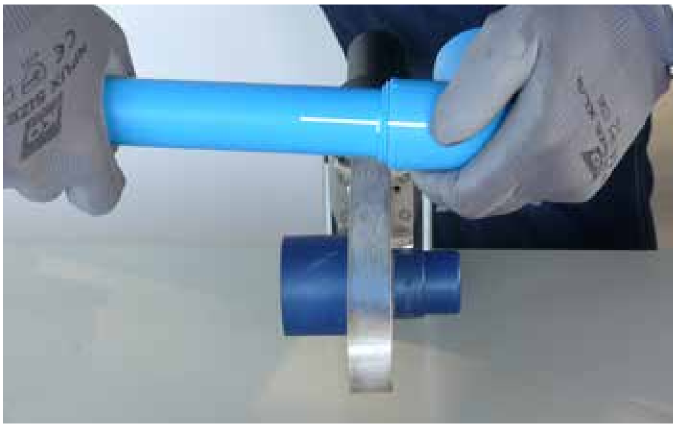


Place the ends to be welded close to each other to be able to begin the heating process of the material simultaneously.



After checking the surface temperature of the die pairs, insert the pipe inside the female die pair without rotating it and the fitting into the male die pair up to the sign previously marked for the heating time t1 as shown in table A (page 76). Do not heat up the parts to be welded twice.

After the heating time, quickly remove the elements from the die pairs and insert them one inside the other, within time t2, until you reach the insertion depth previously marked. Be careful not to rotate the pipe into the fitting and carefully align the reference longitudinal signs.



Once the assembly is complete it is possible to **TEST** it according to the indications as per Standards CEN TR 12108 and EN806-4).

TABLE A

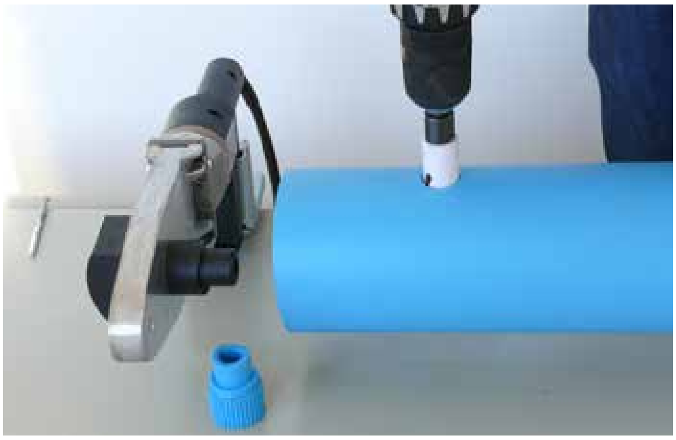
Ø	Heating sec (t1)	Assembly sec (t2)	Test after min	Pipe insertion mm	Welding procedure (Standard DVS 2207 – Sec. 1-6.1)
16	5	4	2	13	• Manual (welder - item code 00NSBEP) • With suitable equipment (welding machines - item code 00STL) • With suitable equipment (welding machines - item code 00STL)
20	5	4	2	14	
25	7	4	3	15	
32	8	6	4	17	
40	12	6	4	18	
50	18	6	4	20	
63	24	8	6	26	
75	30	8	6	29	
90	40	8	6	32	
110	50	10	8	35	
125	60	10	8	40	
160 200 250	Butt fusion welding or electric socket welding				• With suitable equipment
315 355 400 450 500 560 630	Butt fusion welding				• With suitable equipment

3.2.3 POLYFUSION WELDING: WELDING SADDLES

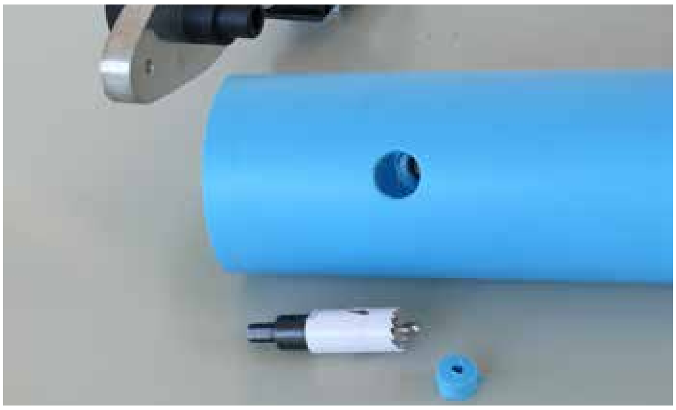
Threaded and not threaded welding saddles allow to make intervals or derivations on large section pipes already installed and also pipe arrays for water meters.

Drill a hole in the pipe with the suitable cutter (item code 00FGS) at the point where you want to make a new derivation.

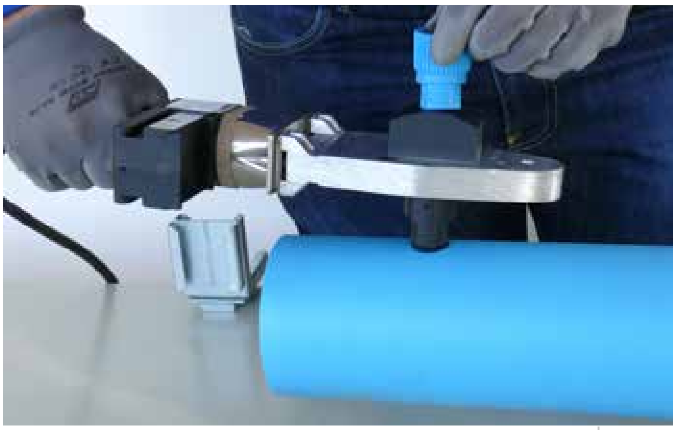
Make sure that the parts to be welded (especially the pipe) are clean and dry.



Check that the welder and die pairs have reached the correct operating temperature (260° C).



Insert the male die pair into the pipe hole until the concave part touches the outer surface of the pipe.



Insert the fitting into the female die pair simultaneously. The contact time between die pairs, fitting and pipe shall be those listed in the relevant table.

Once the heating time is over, immediately insert the welding saddle into the heated hole without turning. The fitting must be perfectly fixed and pressed against the pipe surface for about 30 seconds.

After a cooling time of 10 minutes, the new joint can support the operating parameters.

When making double pipe arrays for water meters we suggest to:

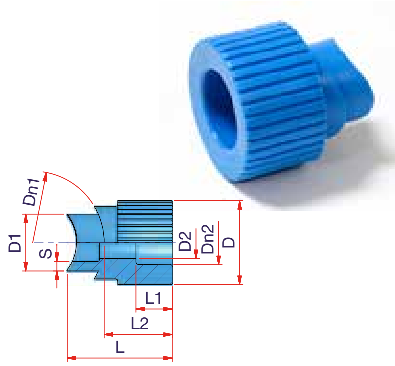
- mark in advance the two opposing drilling axes;
- make all the holes at the same time with the suitable cutter;
- make the joints staggered between them.

3.2.4 DIMENSIONAL TABLE FOR WELDING SADDLES

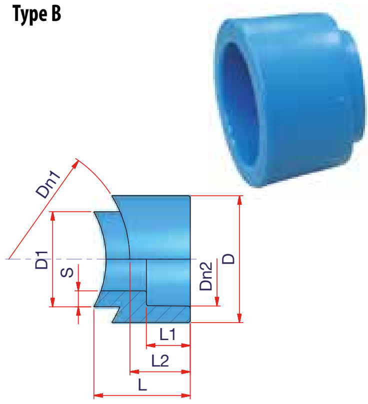
Code	Type	Ø	DN1	DN2	D1
03NGS5020	A	50/25x20	50	20	25
03NGS5025	A	50/25x25	50	25	25
03NGS6320	A	63/25x20	63	20	25
03NGS6325	A	63/25x25	63	25	25
03NGS6332	A	63/32x32	63	32	32
03NGS7520	A	75/25x20	75	20	25
03NGS7525	A	75/25x20	75	25	25
03NGS7532	A	75/32x32	75	32	32
03NGS9020	A	90/25x20	90	20	25
03NGS9025	A	90/25x20	90	25	25
03NGS9032	A	90/32x32	90	32	32
03NGS11020	A	110/25x20	110	20	25
03NGS11025	A	110/25x20	110	25	25
03NGS11032	A	110/32x32	110	32	32
03NGS12563	B	125/63x63	160	40	40
03NGS16040	B	160/40x40	125	63	63
03NGS16063	B	160/63x63	160	63	63

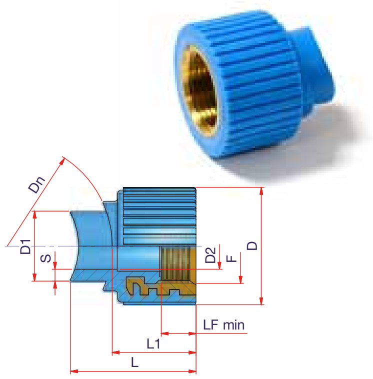
Code	Thread (F)	Ø	DN	D1
03NGSF4012	1/2"	40/25	40	25
03NGSF5012	1/2"	50/25	50	25
03NGSF6312	1/2"	63/25	63	25
03NGSF7512	1/2"	75/25	75	25
03NGSF9012	1/2"	90/25	90	25
03NGSF11012	1/2"	110/25	110	25
03NGSF5034	3/4"	50/25	50	25
03NGSF6334	3/4"	63/25	63	25
03NGSF7534	3/4"	75/25	75	25
03NGSF9034	3/4"	90/25	90	25
03NGSF11034	3/4"	110/25	110	25
03NGSF631	1"	63/32	63	32
03NGSF751	1"	75/32	75	32
03NGSF901	1"	90/32	90	32
03NGSF1101	1"	110/32	110	32

Type A



Type B





00FGS25 ø 25
00FGS32 ø 32

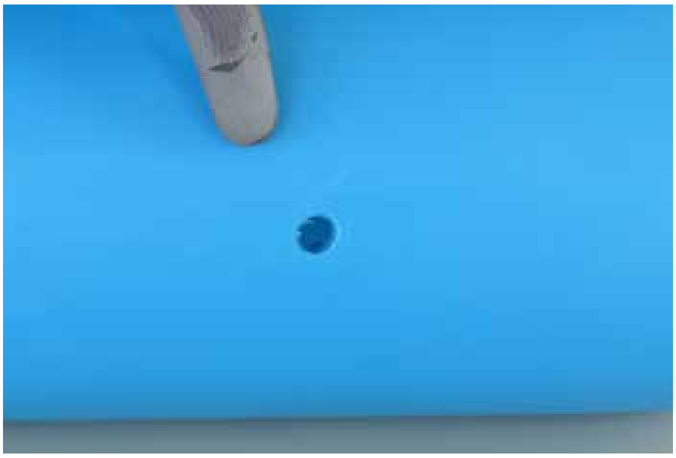
00MATGS40	ø 40/25
00MATGS50	ø 50/25
00MATGS63	ø 63/25
00MATGS75	ø 75/25
00MATGS7532	ø 75/32
00MATGS90	ø 90/25
00MATGS110	ø 110/25
00MATGS6332	ø 63/32
00MATGS9032	ø 90/32
00MATGS11032	ø 110/32

3.2.5 POLYFUSION WELDING: REPAIR OF A DAMAGED PIPE

This system applies when a pipe or a fitting have been pierced just from one side and perpendicularly to their axis.

Enlarge the hole up to a diameter of 6 mm or 10 mm with a suitable tip.

Make sure that the previous hole has not damaged the other inner surface of the pipe or fitting.



Insert the male die pair into the pipe hole and the repair cap into the female die pair.

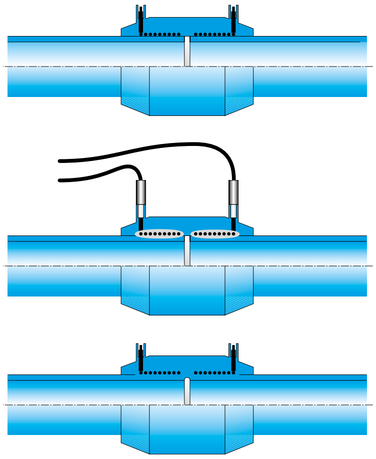
After the insertion, heat up for 5 seconds.

Once the heating time is over, insert the male cap inside the hole without rotating it.

Wait for a cooling time of 1 minute and cut the cap.

The picture shows how the pipe looks after the repair.

3.3 ELECTROFUSION WELDING



Electrofusion fittings are manufactured with a molded-in-place resistance wire which can be connected to suitable welding machines by means of a set of connecting wire leads.

When voltage is applied and electrical energy goes through, this resistance generates the heat needed to melt the PPR.

Energy is directly transmitted to the contact surface between the fitting and the pipe causing heat welding of the parts.

The main features of PPR PIPING SYSTEM electrofusion fittings are the high quality and the reliability of the joints. When it cools down, the joint is homogeneous, strong, safe and reliable.

WELDING BARCODE (in conformity with standard ISO13956)
Scan the barcode with the barcode scanner or manually enter the welding parameters of time and voltage reported on the barcode. You can carry out the welding procedure by using the multifunction welding unit in automatic mode (with barcode scanner) or in manual mode. In case of automatic welding, always check time and voltage parameters on the display after scanning the barcode. In case of manual welding, use time and voltage parameters indicated on the barcode. If the welding unit does not perform welding time compensation according to ambient temperature, use the parameters on the bag label.

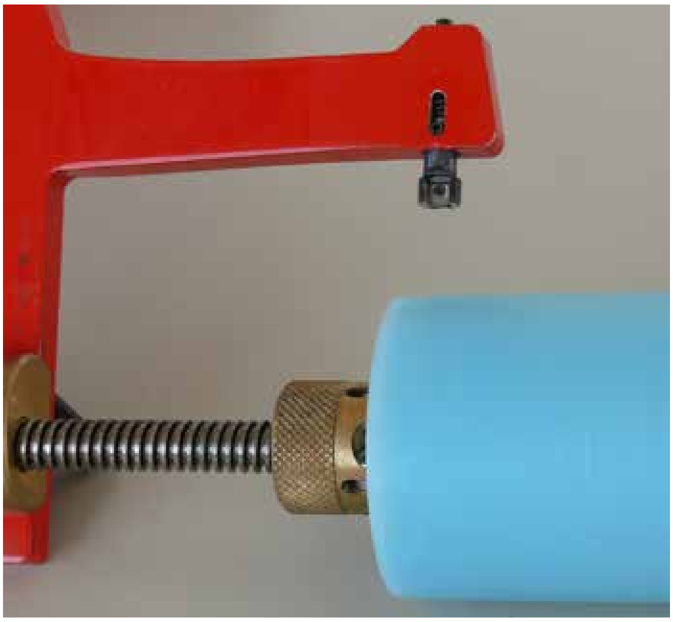
N.B.: Keep at a safe distance during the welding procedure.

Use the PPR PIPING SYSTEM welding units and follow the instructions below to obtain a reliable weld.

Cut the pipes at right angles with a pipe cutter.

Scrape the pipe surface and the fitting spigot uniformly with the appropriate pipe scraper. Scrape at least 1 cm beyond the insertion length of the fitting to completely remove the oxidized polypropylene layer.

Mechanical scrapers are recommended. Hand scrapers can be used.



Remove any mud, dust, grease or other traces of dirt from the pipe or spigot ends and the welding area of the fitting. Use only isopropanol (isopropyl alcohol) and a soft clean wiping cotton cloth. Wait until the cleaned parts are completely dry.

Measure the insertion length of the pipe inside the fitting.

Mark the welding length on the pipe (equal to the length of the electrofusion fitting socket) with the appropriate marker.

Insert the pipe or spigot ends into the fitting up to the marked insertion length (position the aligners in order to keep the position and avoid any mechanical stress during the welding procedure and cooling time if necessary).

AVOID ANY MECHANICAL STRESS ON THE WELDING AREA DURING THE WELDING PROCEDURE AND THE COOLING TIME.

IMPORTANT

Please refer to the user's manual of the welding machine for its correct use.

Prepare the pipe and fitting to be welded following the directions in the previous chapter. Make sure that the pipe and fitting to be welded are lined up without any possibility of movement (use a suitable aligner if necessary).

Connect the welding cables to the fitting connectors, scan the barcode with the barcode scanner or enter the welding parameters manually.

ATTENTION!

Always check the welding parameters before starting the welding procedure.

At the end of the welding procedure, disconnect the cables and wait for the cooling time indicated on the barcode.

The welding data can be downloaded using a USB pen drive or instantly printed through a printer. The exact position of the joint can be recorded with the Bluetooth GPS device (only for model E9001).

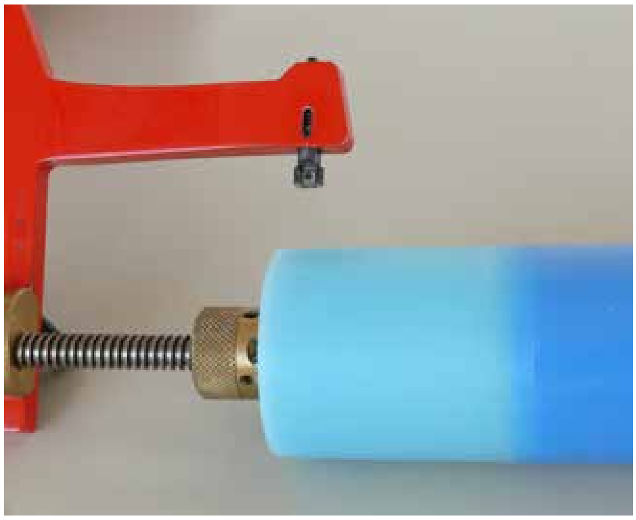
When the cooling time is over, remove the aligners and start the pressure test by using the pressure test unit.

3.3.1 INSTRUCTIONS FOR THE WHITE BLUE AND DARK SYSTEMS

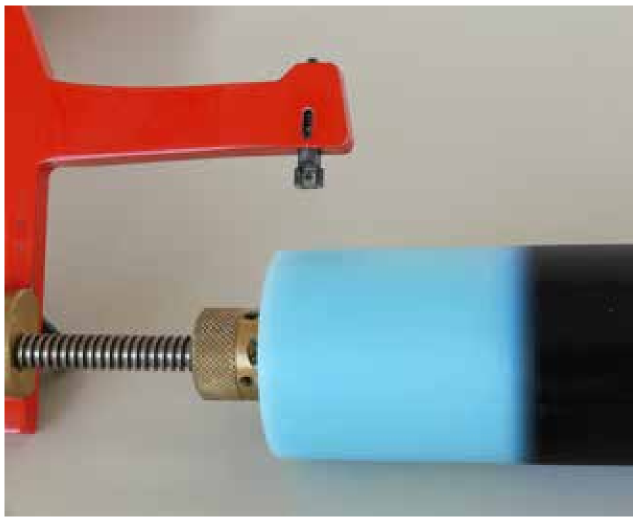
The installation of WHITE BLUE and DARK systems carried out using ELECTROFUSION FITTINGS rather than BUTT FUSION WELDING FITTINGS needs further attention, especially during the preparation of the pipe.

It is essential to completely remove the outer layer of the material until the PPR layer can be seen clearly. This operation makes the welding procedure fully reliable. If it is not performed, the fusion between the PPR used for the production of the fittings and the oxygen barrier or the UV protection layer does not occur.

NIRON® WHITE BLUE PPR PIPE



NIRON® DARK PPR PIPE



3.4 BUTT FUSION WELDING

3.4.1 INTRODUCTION

The welding process consists in the joining of two elements (pipes and/or fittings) of equal diameter and thickness in which the surfaces to be welded are heated until melting by contact with a heating element and then, after its removal, are butt joined by pressure welding.

The instructions below are for guidance only. Unlike socket fusion, butt fusion welding implies that the operators are suitably trained on the use of welding machines and have a thorough knowledge of the procedures to be performed.

ATTENTION!

Each manufacturer of BUTT FUSION WELDING equipment publish his/her own reference literature based on the working parameters of the equipment produced. The user SHALL REFER to this specific literature for every detail not expressly stated and for any reference information regarding the equipment.

3.4.2 RECOMMENDATIONS AND WARNINGS

To perform a proper fusion procedure and ensure a reliable joint, it is necessary to remember the following steps:

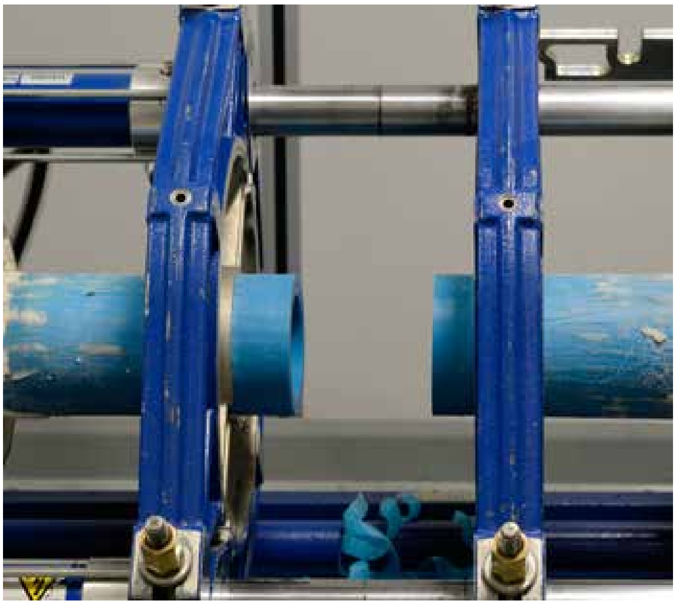
- the working temperature of the heating element shall be checked using a calibrated contact thermometer. This measurement shall be done after about 10 minutes from the moment when the nominal temperature is reached, allowing the heating element to heat up evenly over the entire section;
- check the surface of the heating element (integrity of the non-stick layer) and properly clean it by using soft paper or cloth, free of fibers;
- check the proper functioning of the welding machine;
- check the efficiency of the clamp supports of the welding machine so that the correct alignment of the pieces to be welded and the parallelism of the surfaces touching each other are ensured;
- check the drag force of the movable trolley, both as friction and in relation to the load being handled (pipes and/or fittings);
- check the efficiency of the measuring equipment (pressure gauge and timer);
- check that the pipes and/or fittings to be welded are of the same diameter and thickness (SDR);
- the planing tool supplied with the welding machine shall mill and align the pipes and fittings frontally and also absorb the pressures developed during the welding process without deforming the welding point irreversibly;
- the welding machine should be prepared for use according to the manufacturer's instructions.

3.4.3 BUTT FUSION WELDING PROCEDURE

PREPARATION FOR WELDING

Cleaning the surfaces

Before positioning the parts to be welded, clean the welding area to remove any dust, grease or dirt.



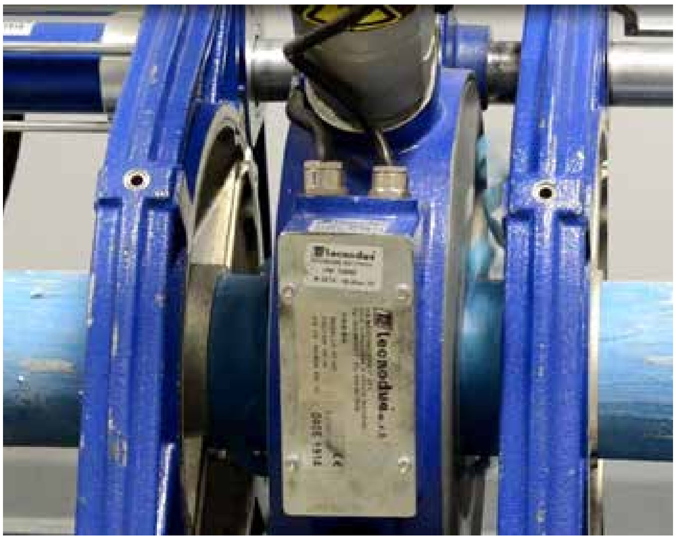
Locking the ends

The pipes and/or fittings must be locked in the clamps of the welding machine so that the contact surfaces to be welded are aligned between them. The possibility of axial movement without significant friction shall be ensured by using rollers or oscillating suspensions to allow the pipe sliding to remove any mechanical stress from the clamps resulting from the weight of the locked pipes.

The pipes and/or fittings shall be positioned so as to contain the misalignment within 10%. To obtain this result, rotate at least one of the elements until the most favorable coupling condition is reached and/or the locking force exerted on the fastening systems of the clamps is not excessive as it could damage the surfaces of the components.

Milling the edges to be welded

The ends of the two components to be welded shall be milled to ensure adequate parallelism and to remove any trace of oxide.



The milling operation shall be carried out by bringing the parties close to each other only when the milling cutter inserted between them is working and by exerting gradual pressure so as not to stop the tool and prevent excessive heating of the surfaces in contact.

The milling chips must be formed continuously on both edges to be welded: otherwise, investigate the cause and repeat the process until the required result is reached.

The milling machine must be turned off only after the removal of the ends to be welded.

After the milling procedure is finished, milling chips shall be removed from the inner surface and the surrounding area of the elements to be welded, by using a brush or a clean cloth, free of fibers, fluff and lint, and not synthetic soaked in a suitable cleaning liquid (e.g. isopropyl alcohol, trichloroethane chlorothene). Do not use any solvent such as gasoline, denatured alcohol or trichlorethylene.

The milled surfaces shall not be touched or otherwise contaminated.

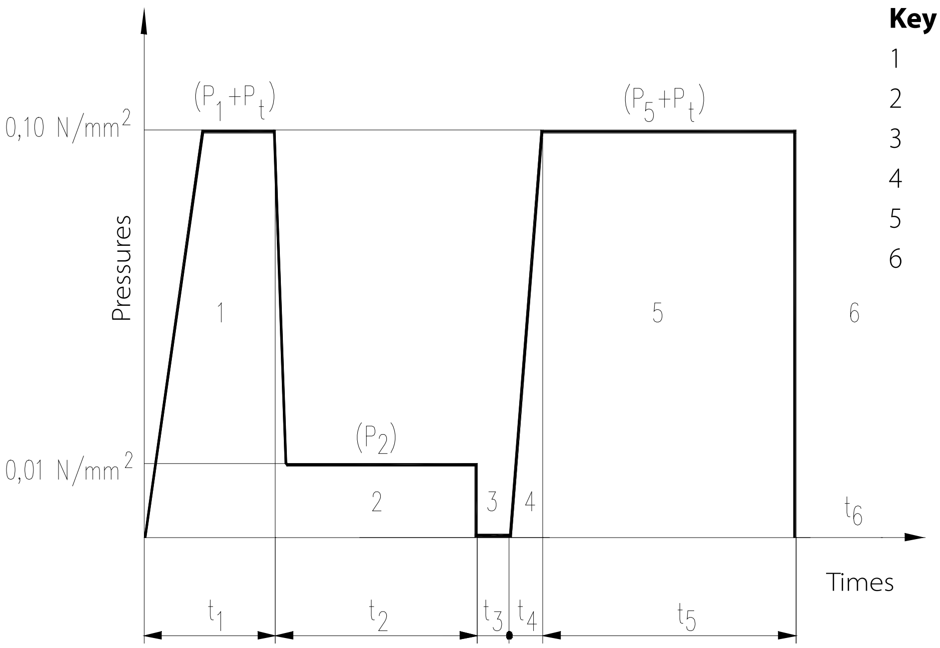
At the end of this phase, by bringing the two ends into contact, the space between the two edges must not exceed the value of 0,5 mm.

WELDING PROCEDURE

Welding procedure by means of contact heating elements

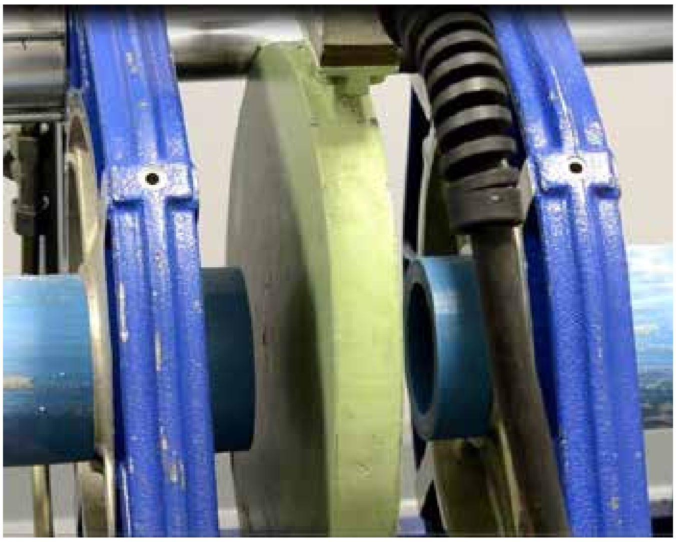
The butt fusion welding of pipes and/or fittings by means of contact heating elements shall be carried out following the different steps of the welding procedure shown in the drawing.

In particular:
Phase 1 : Approaching and preheating
Phase 2 : Heating
Phase 3 : Removing the heating element
Phase 4 : Reaching the welding pressure
Phase 5 : Welding
Phase 6 : Cooling



Key

1 Phase 1 : Approaching and preheating
2 Phase 2 : Heating
3 Phase 3 : Removing the heating element
4 Phase 4 : Reaching the welding pressure
5 Phase 5 : Welding
6 Phase 6 : Cooling



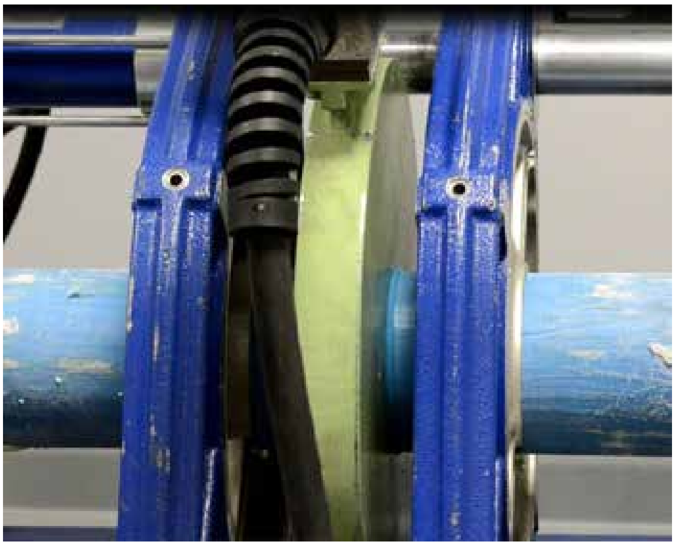
WELDING PHASES

Phase 1: Approaching and preheating

Place the heating element on the welding machine, taking care to insert it properly in order to ensure its stability on the supports of the machine base.

Place the edges close to the heating element, apply the pressure (P1 + Pt) for a time t1 and wait until the bead has reached height h on both welding edges, as shown in table 2 (page 92).

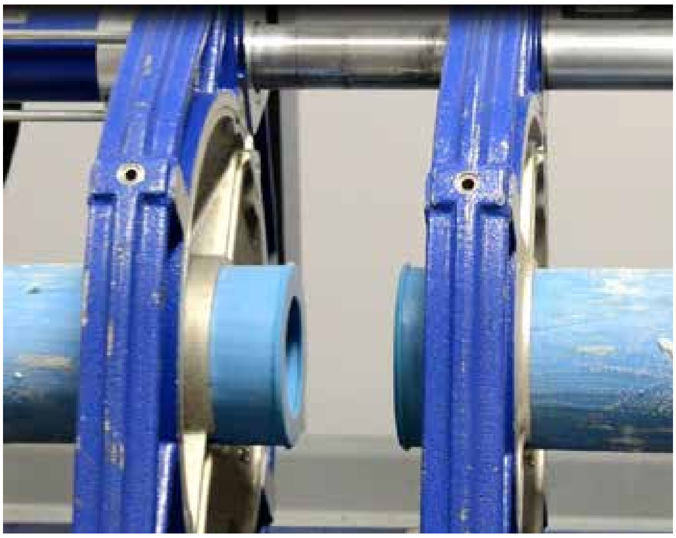
Phase 2: Heating



Once the bead has reached height h, the contact pressure between the edges and the heating element is reduced to the value P2.

Keep the edges in contact with the heating element for the time t2 shown in table 2.

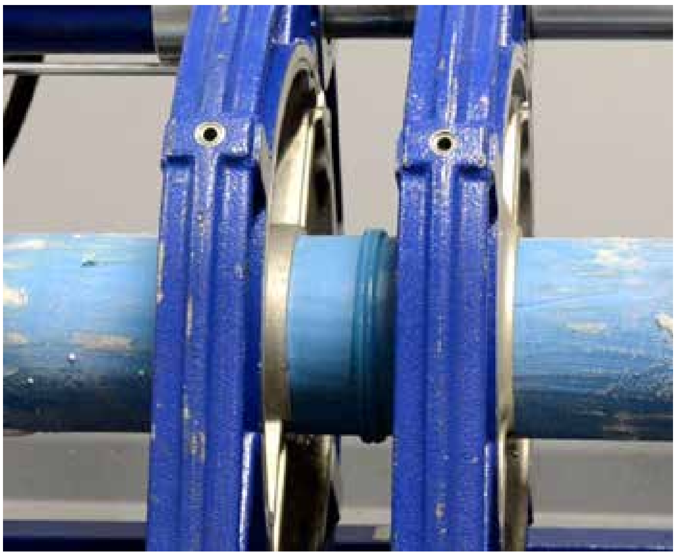
Phase 3: Removing the heating element



Remove the heating element, making sure not to damage the edges of the two parts to be welded.

The removal must be rapid to avoid excessive cooling of the heated edges. Time t3, in seconds, from the removal of the heating element to the contact with the edges (phase 4), however, must be consistent with what is reported in table 2.

Phase 4: Reaching the welding pressure



Once the heating element has been removed, bring the edges into contact. Gradually increase pressure until the value (P5 + Pt) (phase 5) is reached and, anyway, so as to prevent excessive leakage of melted material from the edges in contact. Reaching the welding pressure (P5+ Pt) must take the amount of time t4 shown in table 2.

Phase 5: Welding

Keep the edges in contact under pressure (P5+ Pt) for a time t5, expressed in minutes, as shown in table 2.

Phase 6: Cooling

Once the welding time is over (phase 5), the welded joint can be removed from the welding machine, without being subjected to significant stress. Wait until complete cooling to ambient temperature.

Table 2: Parameters for welding by contact

Wall thickness e_n (mm)	Approaching and Preheating Minimum height of the bead at the end of preheating time under pressure P_1 of 0,10 N/mm² h (mm)	Heating Pressure ≤ 0,01 N/mm² Time t_2 (s)	Removing the heating element Time t_3 max (s)	Reaching the welding pressure Time t_4 max (s)	Welding Pressure = 0,10 N/mm² ± 0,01 Time t_5 min (min)
from .... to		from .... to	from ... to	from ... to	from ... to
2,0 4,5	0,5	60 135	4 5	5 6	3 6
4,5 7	0,5	135 175	5 6	6 7	6 12
7 12	1,0	175 245	6 7	7 11	12 20
12 19	1,0	245 330	7 9	11 17	20 30
19 26	1,5	330 400	9 11	17 22	30 40
26 37	2,0	400 485	11 14	22 32	40 55
37 50	2,5	485 560	14 17	32 43	55 70

N.B.: for thickness values other than those listed, interpolate times linearly for each scheduled interval.

PPR
PIPING
SYSTEM

4

TECHNICAL DATA

4.1 CHEMICAL, PHYSICAL AND MECHANICAL PROPERTIES OF PPR

Characteristics	Test method	Values	Unit of measure
Volumic mass	ISO 1183	0,898	g/cm^3
Yield strength	ISO 527	23	N/mm^2
Elongation at break	ISO 527	> 50	%
Modulus of elasticity	ISO 527	850	N/mm^2
Melt flow index MFI 190/5	ISO 1133 Procedure 18	0,3	g/10 min
Heat conductivity (λ)	DIN 52612	0,24	W/mk
Linear thermal expansion coefficient	VDE 0304	1,5 x 10-4	K^{-1}
Melting range	DIN 53736b2	150 - 154	°C
Impact strength (Charpy) +23°C	ISO 179/1 e A	no break	KJ/m^2
-30°C	ISO 179/1 e A	50	KJ/m^2
Volumic strength	IEC 93	>10^{15}	Ω cm
Dielectric strength	IEC 243/1	75	KV/mm
Fire resistance	DIN 4102	B2	

4.2 THE PIPE

PPR PIPING SYSTEM pipes are manufactured in accordance with standards UNI EN ISO 15874 and ISO21003 and are divided into:

- MONOLAYER PIPES
- MULTILAYER PIPES

They are sized to meet the needs of different types of installation.
The maximum constant pressure in bar at 20° C for 50 years, is obtained by the relation:

$$PN = \frac{20 \cdot \sigma}{C \cdot (SDR - 1)}$$

where:
PN = Nominal Pressure (bar)
σ = Hoop Stress of PPR (MPa)
SDR = Standard Dimension Ratio (External Diameter/Thickness)
C = Safety Coefficient

The European Standard **UNI EN ISO 15874** includes the classification of PPR piping systems intended to be used for hot and cold water installations. The **PPR PIPING SYSTEM** by **NUPIGECO** meets these requirements by ensuring a performance as per classes 1, 2 and 4 listed in the table below and classe 5 thanks to PP-RP.

EUROPEAN STANDARD
UNI EN ISO 15874

Class	T_{oper} (°C)^2	Years to T_{oper}	Pressure Bar	T_{max} (°C)^2	Years at T_{max}	T_{mal} (°C)^2	Hours at T_{mal}	Fields of use
1	60	49	10	80	1	95	100	Hot water (60°C)
2	70	49	8	80	1	95	100	Hot water (70°C)
4	20	2,5	10	70	2,5	100	100	Floor heating and heating at max temperature 70°C
	Followed by							
	40	20						
	Followed by							
	60	25						
5	20	14	10	90	1	100	100	High temperature heating systems
	Followed by							
	60	25						
	Followed by							
	80	10						

Note 1: if more than one operating temperature is present in only one class, times must be combined.
For example, the operating temperature expected for 50 years for class 2 is 70° C for 49 years combined with 80° C for 1 year and 95° C for 100 hours.

Note 2: for values of T_{oper} (working temperature), T_{max} (maximum working temperature) and T_{mal} (malfunctioning temperature) higher than those indicated in the table, these standards are not applicable.

4.3 THERMAL EXPANSION

Plastic pipes are subject to thermal expansion, a phenomenon that has to be taken into consideration to prevent any possible damage.

The thermal expansion or contraction of a plastic pipe can be calculated using formula B.1 below and the coefficients of thermal expansion shown in the following table.

COEFFICIENT OF LINEAR THERMAL EXPANSION FOR PLASTIC PIPING

Pipe material	α (mm/mK)
PE	0,20
PE-X	0,15
PP	0,15
PB	0,13
PE-RT	0,19

$$\Delta L = \alpha \, L \, \Delta T$$

(FORMULA B.1)

Symbol	Description	Value	Unit of measure	
ΔL =	linear thermal expansion		mm	millimeters
αf =	coefficient of linear thermal expansion of monolayer PPR pipes	0,15	mm/mK	millimeters/meter kelvin
α(FG) =	coefficient of linear thermal expansion of PPR pipes with fiber glass	0,035	mm/mK	millimeters/meter kelvin
L =	pipe length		m	meters
ΔT =	difference between the installation temperature and the temperature of the transported fluid		K	degrees Kelvin

We hereby suggest some solutions to compensate the effects of linear expansion according to the different types of installation:

- **INSIDE WALL INSTALLATION**
- **INSTALLATION ON HORIZONTAL CONTINUOUS SUPPORTS**
- **FREE INSTALLATION**

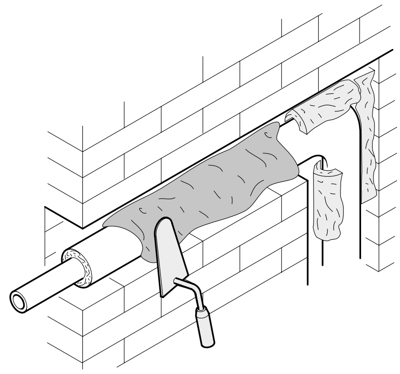
INSIDE WALL INSTALLATION

- **Non-insulated pipe:** the expansion will spread inside the pipe.
- **Insulated pipe:** the expansion will slightly compress the insulation layer to compensate the elongation.

Inside wall installation has always been the most recommended kind of installation for monolayer PP-R pipes because it avoids direct exposure to UV rays and benefits from a lower linear expansion as the outer layer is completely in contact with a large exchange area:

- the pipe can be walled directly in contact with plaster, lime and cement;

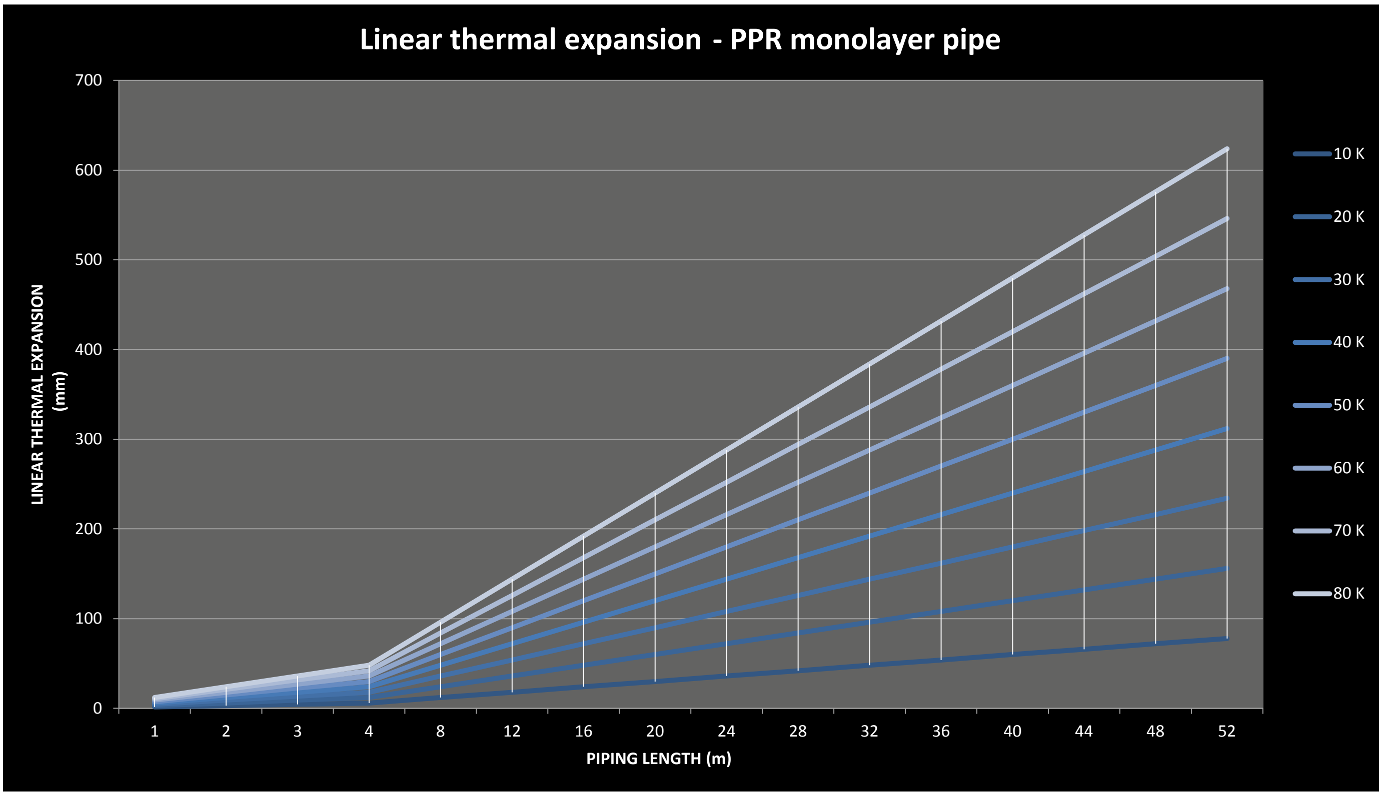
- the expansion does not carry the force required to remove the tiles and/or break the plaster.



INSIDE WALL INSTALLATION

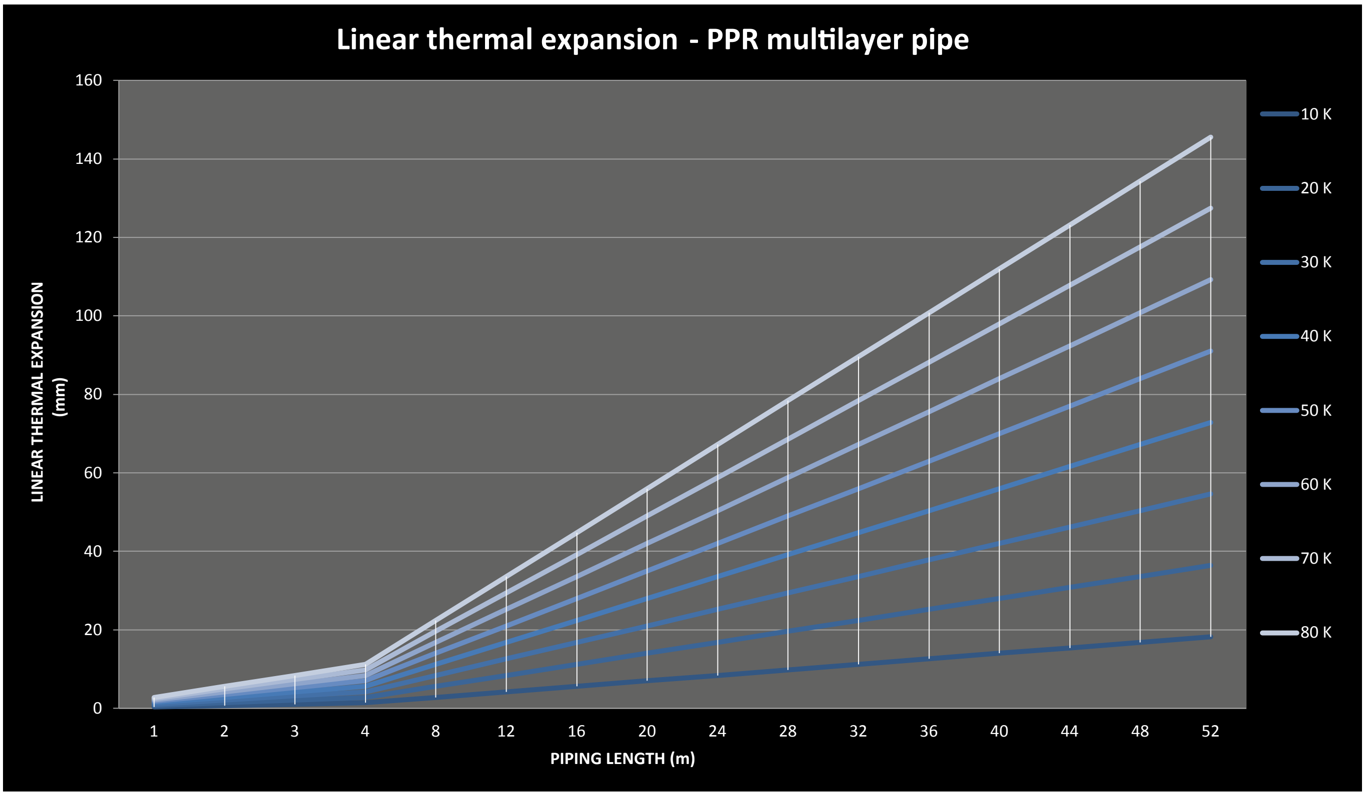
LINEAR THERMAL EXPANSION FOR MONOLAYER PPR PIPES

	ΔT = T fluid - T installation							
	10 K	20 K	30 K	40 K	50 K	60 K	70 K	80 K
L (m)	ΔL (mm)							
1	1,5	3,0	4,5	6,0	7,5	9,0	10,5	12,0
2	3,0	6,0	9,0	12,0	15,0	18,0	21,0	24,0
3	4,5	9,0	13,5	18,0	22,5	27,0	31,5	36,0
4	6,0	12,0	18,0	24,0	30,0	36,0	42,0	48,0
8	12,0	24,0	36,0	48,0	60,0	72,0	84,0	96,0
12	18,0	36,0	54,0	72,0	90,0	108,0	126,0	144,0
16	24,0	48,0	72,0	96,0	120,0	144,0	168,0	192,0
20	30,0	60,0	90,0	120,0	150,0	180,0	210,0	240,0
24	36,0	72,0	108,0	144,0	180,0	216,0	252,0	288,0
28	42,0	84,0	126,0	168,0	210,0	252,0	294,0	336,0
32	48,0	96,0	144,0	192,0	240,0	288,0	336,0	384,0
36	54,0	108,0	162,0	216,0	270,0	324,0	378,0	432,0
40	60,0	120,0	180,0	240,0	300,0	360,0	420,0	480,0
44	66,0	132,0	198,0	264,0	330,0	396,0	462,0	528,0
48	72,0	144,0	216,0	288,0	360,0	432,0	504,0	576,0
52	78,0	156,0	234,0	312,0	390,0	468,0	546,0	624,0



LINEAR THERMAL EXPANSION FOR MULTILAYER PPR PIPES WITH FIBER GLASS

	ΔT = T fluid - T installation							
	10 K	20 K	30 K	40 K	50 K	60 K	70 K	80 K
L (m)	ΔL (mm)							
1	0,4	0,7	1,1	1,4	1,8	2,1	2,5	2,8
2	0,7	1,4	2,1	2,8	3,5	4,2	4,9	5,6
3	1,1	2,1	3,2	4,2	5,3	6,3	7,4	8,4
4	1,4	2,8	4,2	5,6	7,0	8,4	9,8	11,2
8	2,8	5,6	8,4	11,2	14,0	16,8	19,6	22,4
12	4,2	8,4	12,6	16,8	21,0	25,2	29,4	33,6
16	5,6	11,2	16,8	22,4	28,0	33,6	39,2	44,8
20	7,0	14,0	21,0	28,0	35,0	42,0	49,0	56,0
24	8,4	16,8	25,2	33,6	42,0	50,4	58,8	67,2
28	9,8	19,6	29,4	39,2	49,0	58,8	68,6	78,4
32	11,2	22,4	33,6	44,8	56,0	67,2	78,4	89,6
36	12,6	25,2	37,8	50,4	63,0	75,6	88,2	100,8
40	14,0	28,0	42,0	56,0	70,0	84,0	98,0	112,0
44	15,4	30,8	46,2	61,6	77,0	92,4	107,8	123,2
48	16,8	33,6	50,4	67,2	84,0	100,8	117,6	134,4
52	18,2	36,4	54,6	72,8	91,0	109,2	127,4	145,6



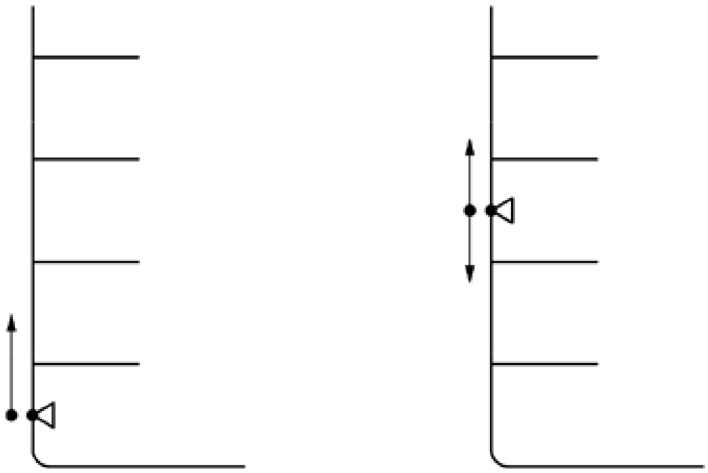
4.3.1 INSTALLATIONS WHERE THERMAL EXPANSION IS ALLOWED (UNI EN 806-4)

Pipes can be laid on a continuous horizontal supports (rails), where the elongation is compensated by the pipe snaking. The pipe trail should be designed so as to leave enough space for the elongation or contraction of the pipe. It is advisable to secure the pipe to avoid its vertical movement.

POSITIONING OF ANCHOR POINTS

The positioning of anchor points can be used to give direction to and to limit the amount of thermal expansion. Examples are given in Figures B.1, B.2 and B.3.
This is also valid for mains in a basement.

FIGURE B.1 - POSITIONING OF ANCHOR POINTS (INSTALLATION WITH BRANCHES)



INSTALLATION OF PIPES ALLOWING EXPANSION BY MEANS OF A FLEXIBLE ARM

The flexible arm should be sufficiently long to prevent any damage.
The brackets should allow clearance to the wall after expansion. This is also applicable in cases where pipes are supported along their length.
A typical installation is shown in Figures B.2 and B.3.

FIGURE B.2 - COMPENSATION OF EXPANSION ΔL BY FLEXIBLE ARM

Key
ΔL Length difference
L Length of pipe section
L_B Length of flexible arm
o Anchor point

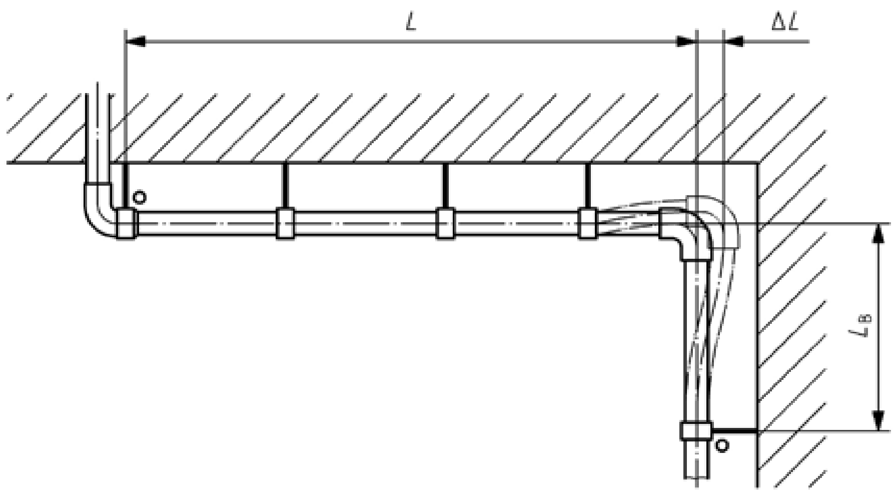
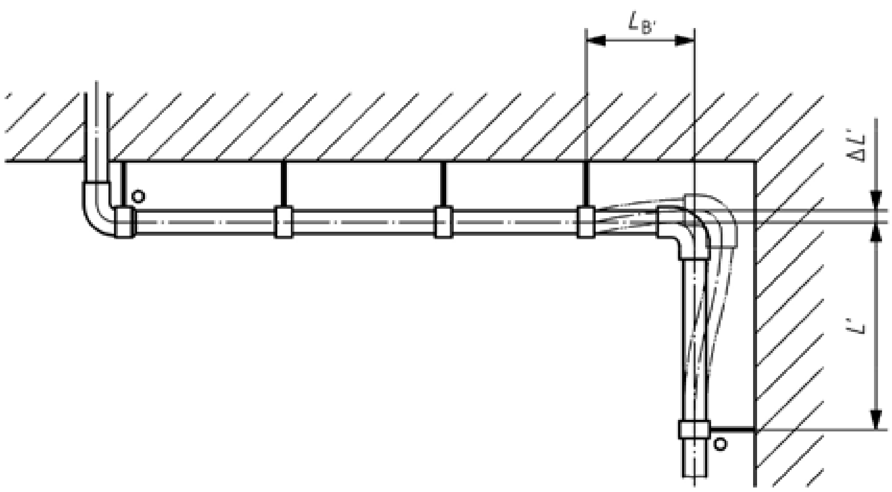


FIGURE B.3 - COMPENSATION OF EXPANSION ΔL BY FLEXIBLE ARM

Key
$\Delta L'$ Length difference
L' Length of pipe section
L_B' Length of flexible arm
o Anchor point



The length of the flexible arm, L_B can be calculated from the formula B.2 below:

$$L_B = C \times \sqrt{d_e \times \Delta L}$$

where

L_B is the length of the flexible arm, in mm;
C is the materiai constant in accordance with Table B.4;
d_e is the outside diameter, in mm;
ΔL is the thermal length variation as determined by formula B.1, in mm.

TABLE B.4 - VALUES OF MATERIAL CONSTANT C

Material	C
PE	27
PE-X	12
PP	20
PB	10
PE-RT	14

INSTALLATION OF PIPES ALLOWING EXPANSION BY MEANS OF AN EXPANSION LOOP

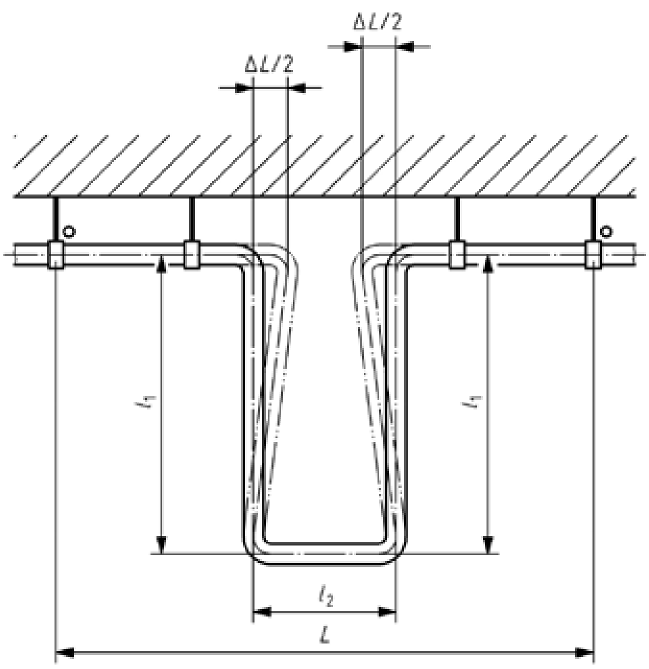
A typical installation is shown in Figure B.4.

FIGURE B.4 - COMPENSATION OF THE THERMAL EXPANSION BY EXPANSION LOOP

Key

See explanations to formula (B.3).

L Distance between fixed brackets
l_1 Length of loop
l_2 Width of loop
ΔL Linear thermal expansion
o Anchor point



The length of the flexible arm, L_B can be calculated from the following formula:

$$L_B = C \times \sqrt{d_e \times \frac{2 x \Delta L}{2}} = 2 x l_1 + l_2$$

where

L_B is the length of the flexible arm, in mm;

C is the material constant;

d_e is the outside diameter, in mm;

ΔL is the linear thermal expansion, in mm;

l_1 is the length of loop, in mm;

l_2 is the width of loop, in mm.

It is preferable to design the loop so that $l_2 = 0{,}5\ l_1$.

The expansion loop is also calculated using formula B.3. In this case the flexible arm $L_B = l_1 + l_1 + l_2$.

INSTALLATION OF PIPES ALLOWING EXPANSION AND WITH CONTINUOUS SUPPORT AND GUIDE BRACKETS

A typlcal installation is shown in Figure B.5.

FIGURE B.5 - CONTINUOUS SUPPORT WITH GUIDE BRACKETS ALLOWING EXPANSION

Key

1 Continuous support

L_1 Distance between supporting guide bracket or between supporting guide bracket and anchor point

L_2 Distance between bindings

Maximum distances between guide brackets and bindings are given in Tables B.5 and B.6.

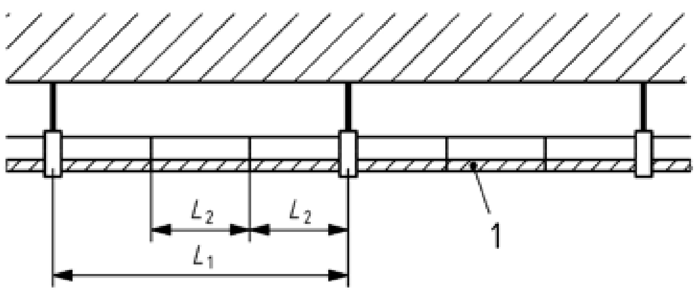


TABLE B.5 - DISTANCE L_1 (APPROXIMATE VALUES)

Pipe outside diameter mm	L_1 mm	
	Cold water	Hot water
≤ 20	1500	1000
> 20 to ≤ 40	1500	1200
> 40 to ≤ 75	1500	1500
> 75 to ≤ 110	2000	2000
* > 125 to ≤ 160	2500	2500
* > 160 to ≤ 250	3000	3000

* not included in UNI EN806-4

TABLE B.6 - DISTANCE L_2 (APPROXIMATE VALUES)

Pipe outside diameter mm	L_2 mm	
	Cold water	Hot water
≤ 20	500	200
> 20 to ≤ 25	500	300
> 25 to ≤ 32	750	400
> 32 to ≤ 40	750	600
> 40 to ≤ 75	750	750
> 75 to ≤ 110	1000	1000
* > 110 to ≤ 125	1000	1000
* > 125 to ≤ 250	1250	1250

* not included in UNI EN806-4

INSTALLATION OF PIPES ALLOWING EXPANSION AND WITH GUIDE BRACKETS

Maximum distance between guide brackets are shown in Table B.7.

TABLE B.7 - DISTANCE L_1 (APPROXIMATE VALUES)

Pipe outside diameter mm	L_1 mm	
	Cold water	Hot water
≤ 16	750	400
> 16 to ≤ 20	800	500
> 20 to ≤ 25	850	600
> 25 to ≤ 32	1000	650
> 32 to ≤ 40	1100	800
> 40 to ≤ 50	1250	1000
> 50 to ≤ 63	1400	1200
> 63 to ≤ 75	1500	1300
> 75 to ≤ 90	1650	1450
> 90 to ≤ 110	1900	1600
* > 125 to ≤ 160	2100	1850
* > 160 to ≤ 200	2500	2300
* > 200 to ≤ 250	2800	2500

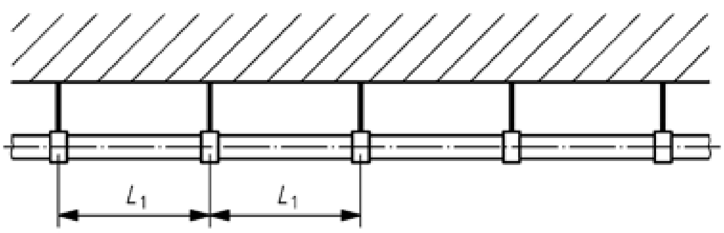
* not included in UNI EN806-4

For vertical pipes L_1 should be multiplied by 1,3.

FIGURE B.6 - GUIDE BRACKETS ALLOWING EXPANSION

Key

L_1 Distance between guide brackets or between guide bracket and anchor point



INSTALLATION OF PIPES ON CONTINUOUS HORIZONTAL SUPPORTS

Pipes may be laid down on continuous horizontal support (i.e. cable path), where the elongation is compensated by "snaking" of the pipe. The course of the pipe should be designed to give enough space for elongation or contraction of the pipe. To avoid vertical movement of the pipe, the pipe should be secured.

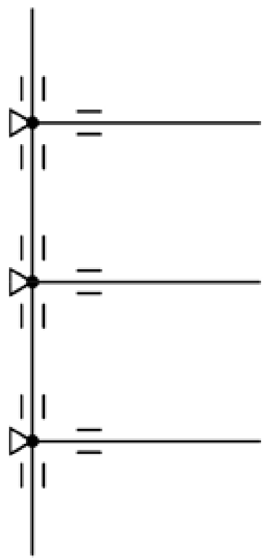
4.3.2 INSTALLATION OF PIPES NOT ALLOWING EXPANSION

Installation of pipes between anchor points is sometimes required for special situations, in this case the force due to thermal expansion and contraction is transmitted through the supports to the buildings structure. Examples are given in Figures B.7, B.8, B.9 and B.10.

POSITIONING OF ANCHOR POINTS

The anchor points are positioned so that the thermal variations cannot take place. The maximum allowable distance between anchor points should be below or equal to 6 m.

FIGURE B.7 - POSITIONING OF ANCHOR POINTS AT BRANCHES



INSTALLATION BETWEEN ANCHOR POINTS WHERE CONTINUOUS PIPE STIFFENING IS PROVIDED

Maximum distances between different fixings as shown in Figure B.8 should conform to Tables B.5 and B.6.

FIGURE B.8 - CONTINUOUS SUPPORT NOT ALLOWING EXPANSION

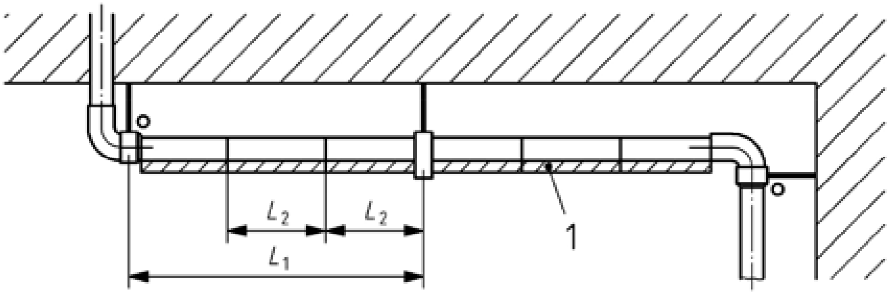
Key

1 Continuous support

L_1 Distance between guide brackets or between guide bracket and anchor point (see Table B.5)

L_2 Distance between bindings (see Table B.6)

o Anchor point



INSTALLATION BETWEEN ANCHOR POINTS WITH GUIDE BRACKETS

FIGURE B.9 - INSTALLATION BETWEEN ANCHOR POINTS WITH GUIDE BRACKETS

Key

L_1 Distance between guide brackets or between guide bracket and anchor point

o Anchor point

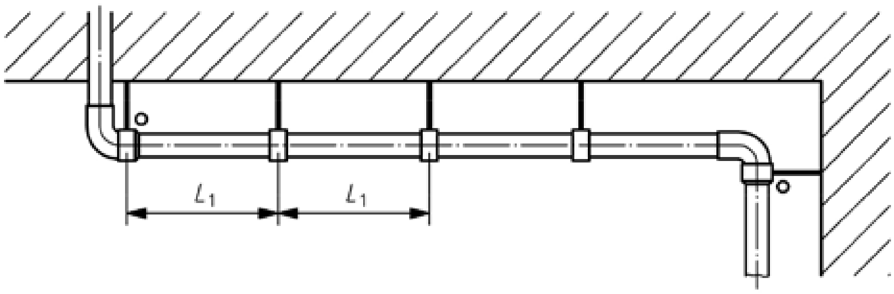


TABLE B.8 - DISTANCE L_1 (APPROXIMATE VALUES)

Pipe outside diameter mm	L_1 mm	
	Cold water	Hot water
≤ 16	750	400
> 16 to ≤ 20	800	500
> 20 to ≤ 25	850	600
> 25 to ≤ 32	1000	650
> 32 to ≤ 40	1100	800
> 40 to ≤ 50	1250	1000
> 50 to ≤ 63	1400	1200
> 63 to ≤ 75	1500	1300
> 75 to ≤ 90	1650	1450
> 90 to ≤ 110	1900	1600
* > 110 to ≤ 160	2000	1400
* > 160 to ≤ 200	2300	1800
* > 200 to ≤ 250	2500	2000

* not included in UNI EN806-4

Maximum distance between anchor points and guide brackets as shown in Figure B.9 should conform to Table B.8.

INSTALLATION OF PIPES SUPPORTED ONLY AT THE ANCHOR POINTS

In this case, the forces due to thermal expansion and contraction only partially are transmitted through the anchor points to the building structure.
This may be used where the movement caused by thermal expansion as shown in Figure B.10, can be tolerated and/or is visually acceptable.

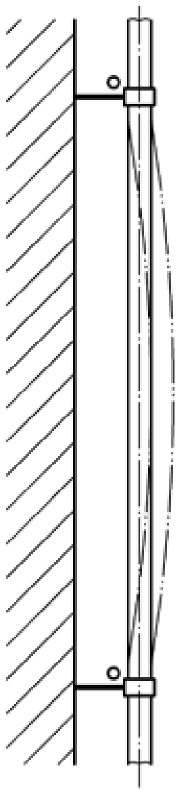


FIGURE B.10 - PIPES SUPPORTED ONLY BY ANCHOR POINTS

Key
o Anchor point

4.4 HEAT LOSS

Law 10/91 and DPR 412/93 require that the hot water temperature at the point of use is 48°C + 5 and require the insulation of all piping.

The thickness of the insulation layer depends on its thermal conductivity and on the pipe diameter.

PPR PIPING SYSTEM pipes, both insulated and non-insulated, have very low heat loss and allow to meet the required values as can be seen in the following tables.

N.B.:

Please contact NUPIGECO Technical Office for heat loss values according to different water speed, pipe SDR, thermal conductivity of the insulation layer and ambien temperature.

NON-INSULATED PIPE
Water temp. 40°C – Speed 2 m/s

Ø mm	SDR	Ambient temperature 10°C	15°C	20°C
		Heat loss °C every 10m of pipe		
20	6	0,25	0,21	0,17
25	6	0,18	0,15	0,12
32	6	0,13	0,11	0,09
40	6	0,09	0,08	0,06
50	6	0,07	0,06	0,05
63	6	0,05	0,04	0,03
75	6	0,04	0,03	0,02
90	6	0,03	0,02	0,02
110	6	0,02	0,02	0,02
125	6	0,02	0,01	0,01

NON-INSULATED PIPE
Water temp. 40°C – Speed 2 m/s

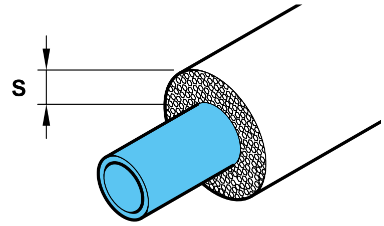
Ø mm	SDR	Ambient temperature 10°C	15°C	20°C
		Heat loss °C every 10m of pipe		
25	7,4	0,17	0,14	0,11
32	7,4	0,12	0,10	0,08
40	7,4	0,09	0,07	0,06
50	7,4	0,07	0,06	0,05
63	7,4	0,05	0,04	0,03
75	7,4	0,04	0,03	0,02
90	7,4	0,03	0,02	0,02
110	7,4	0,02	0,02	0,01
125	7,4	0,02	0,01	0,01
160	7,4	0,01	0,01	0,00

INSULATED PIPE
Water temp. 40°C – Speed 2 m/s

Ø mm	SDR	Insulation layer 0,038 W/mk thickness	Ambient temperature 10°C	15°C	20°C
			Heat loss °C every 10m of pipe		
20	6	6	0,10	0,08	0,07
25	6	9	0,05	0,05	0,04
32	6	9	0,04	0,03	0,03
40	6	9	0,03	0,02	0,02
50	6	12	0,02	0,02	0,01
63	6	15	0,01	0,01	0,01
75	6	15	0,01	0,00	0,00
90	6	17	0,00	0,00	0,00
110	6	18	0,00	0,00	0,00
125	6	18	0,00	0,00	0,00

INSULATED PIPE
Water temp. 40°C – Speed 2 m/s

Ø mm	SDR	Insulation layer 0,038 W/mk thickness	Ambient temperature 10°C	15°C	20°C
			Heat loss °C every 10m of pipe		
25	7,4	9	0,05	0,04	0,03
32	7,4	9	0,04	0,03	0,02
40	7,4	9	0,03	0,02	0,02
50	7,4	12	0,02	0,01	0,01
63	7,4	15	0,01	0,00	0,00
75	7,4	15	0,01	0,00	0,00
90	7,4	17	0,00	0,00	0,00
110	7,4	18	0,00	0,00	0,00
125	7,4	18	0,00	0,00	0,00
160	7,4	18	0,00	0,00	0,00



s = Thickness of the insulation layer in mm with a conductivity value of 0.038 W/mk
Te = Outside air temperature in °C
Ti = Water temperature inside the pipes in °C
60%/80% = Relative humidity of air

4.5 ANTI-CONDENSATION INSULATION IN AIR CONDITIONING SYSTEMS

The tables below indicate the minimum thickness of insulation required for PPR PIPING SYSTEM pipes to avoid that moisture present in the air turns into dew on the pipes in air conditioning systems.

PIPE Ø 20 x 3,4 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,7	3,9	4,1	4,3	4,6	4,8	5,0	5,3	5,5	
7	3,0	3,3	3,5	3,8	4,0	4,2	4,5	4,7	5,0	60
9	2,4	2,7	2,9	3,2	3,4	3,7	3,9	4,2	4,4	
5	10,5	10,9	11,3	11,7	12,1	12,4	12,8	13,2	13,6	
7	9,5	9,9	10,3	10,7	11,1	11,5	11,9	12,3	12,7	80
9	8,4	8,8	9,2	9,6	10,0	10,5	10,9	11,3	11,7	

PIPE Ø 25 x 4,2 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,6	3,8	4,1	4,3	4,6	4,8	5,1	5,3	5,6	
7	3,0	3,2	3,5	3,7	4,0	4,2	4,5	4,8	5,0	60
9	2,3	2,6	2,9	3,1	3,4	3,7	3,9	4,2	4,4	
5	10,9	11,3	11,7	12,1	12,5	12,9	13,3	13,7	14,1	
7	9,7	10,2	10,6	11,0	11,4	11,9	12,3	12,7	13,1	80
9	8,6	9,0	9,5	9,9	10,3	10,8	11,2	11,7	12,1	

PIPE Ø 32 x 5,4 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,5	3,8	4,0	4,3	4,5	4,8	5,0	5,3	5,5	
7	2,9	3,1	3,4	3,6	3,9	4,2	4,4	4,7	5,0	60
9	2,2	2,5	2,7	3,0	3,3	3,6	3,8	4,1	4,4	
5	11,1	11,6	12,0	12,4	12,9	13,3	13,7	14,1	14,6	
7	10,0	10,4	10,9	11,3	11,8	12,2	12,7	13,1	13,5	80
9	8,7	9,2	9,7	10,1	10,6	11,1	11,6	12,0	12,5	

PIPE Ø 40 x 6,7 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,4	3,6	3,9	4,4	4,7	4,9	4,9	5,2	5,5	
7	2,7	3,0	3,2	3,8	4,1	4,3	4,3	4,6	4,9	60
9	2,0	2,3	2,6	3,1	3,4	3,7	3,7	4,0	4,3	
5	11,3	11,8	12,3	13,2	13,6	14,1	14,1	14,5	15,0	
7	10,1	10,6	11,0	13,0	12,5	12,9	12,9	13,4	13,9	80
9	8,8	9,3	9,8	10,8	11,3	11,8	11,8	12,3	12,8	

PIPE Ø 50 x 8,4 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,1	3,4	3,7	4,0	4,2	4,5	4,8	5,0	5,3	
7	2,4	2,7	3,0	3,3	3,6	3,8	4,1	4,4	4,7	60
9	1,7	2,0	2,3	2,6	2,9	3,2	3,5	3,8	4,1	
5	11,5	11,9	12,4	12,9	13,4	13,8	14,3	14,8	15,3	
7	10,1	10,6	11,1	11,6	12,1	12,6	13,1	13,6	14,1	80
9	8,8	9,3	9,8	10,4	10,9	11,4	11,9	12,4	13,0	

PIPE Ø 63 x 10,5 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	2,8	3,1	3,4	3,7	4,0	4,2	4,5	4,8	5,1	
7	2,1	2,4	2,7	3,0	3,3	3,6	3,8	4,1	4,4	60
9	1,4	1,7	2,0	2,3	2,6	2,9	3,2	3,5	3,8	
5	11,5	12,0	12,5	13,0	13,5	14,0	14,5	15,0	15,5	
7	10,1	10,6	11,2	11,7	12,2	12,7	13,2	13,8	14,3	80
9	8,7	9,2	9,8	10,3	10,9	11,4	12,0	12,5	13,1	

PIPE 75 x 12,5 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	2,3	2,6	2,9	3,2	3,5	3,8	4,1	4,4	4,7	
7	1,6	1,9	2,2	2,5	2,8	3,1	3,4	3,7	4,0	60
9	0,9	1,2	1,5	1,8	2,1	2,4	2,7	3,0	3,3	
5	11,1	11,6	12,1	12,6	13,1	13,6	14,1	14,6	15,1	
7	9,7	10,2	10,7	11,2	11,7	12,2	12,7	13,2	13,7	80
9	8,2	8,8	9,4	10,0	10,6	11,2	11,8	12,4	13,0	

PIPE Ø 90 x 15 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	1,8	2,1	2,4	2,7	3,0	3,3	3,6	3,9	4,2	
7	1,1	1,5	1,7	2,0	2,3	2,6	2,9	3,2	3,5	60
9	0,3	0,6	0,9	1,2	1,5	1,8	2,1	2,4	2,7	
5	10,8	11,4	11,9	12,5	13,0	13,6	14,1	14,7	15,2	
7	9,4	10,0	10,5	11,1	11,6	12,2	12,7	13,3	13,8	80
9	7,9	8,5	9,0	9,6	10,1	10,7	11,2	11,8	12,3	

PIPE Ø 110 x 18,4 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	1,3	1,6	1,9	2,2	2,5	2,8	3,1	3,4	3,7	
7	0,5	0,8	1,1	1,4	1,7	2,0	2,3	2,6	2,9	60
9	0,0	0,1	0,4	0,7	1,0	1,3	1,6	1,9	2,2	
5	10,5	11,1	11,6	12,2	12,7	13,3	13,8	14,4	14,9	
7	9,0	9,6	10,1	10,7	11,2	11,8	12,3	12,9	13,4	80
9	7,5	8,1	8,7	9,3	9,9	10,5	11,1	11,7	12,3	

PIPE Ø 125 x 20,8 SDR 6

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	0,8	1,1	1,4	1,7	2,0	2,3	2,6	2,9	3,2	
7	0,0	0,3	0,6	0,9	1,2	1,5	1,8	2,1	2,4	60
9	0,0	0,0	0,0	0,2	0,5	0,8	1,1	1,4	1,7	
5	10,2	10,8	11,3	11,9	12,4	13,0	13,5	14,1	14,6	
7	8,6	9,2	9,8	10,4	11,0	11,6	12,2	12,8	13,4	80
9	7,1	7,7	8,3	8,9	9,5	10,1	10,7	11,3	11,9	

PIPE Ø 20 x 2,8 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,8	4,0	4,3	4,5	4,7	5,0	5,2	5,4	5,6	
7	3,2	3,5	3,7	4,0	4,2	4,5	4,7	5,0	5,2	60
9	2,6	2,9	3,1	3,4	3,6	3,9	4,1	4,4	4,6	
5	10,6	11,0	11,4	11,8	12,2	12,6	13,0	13,4	13,8	
7	9,6	10,0	10,4	10,8	11,2	11,6	12,0	12,4	12,8	80
9	8,5	8,9	9,3	9,7	10,1	10,5	10,9	11,3	11,7	

PIPE Ø 25 x 3,5 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,8	4,0	4,3	4,5	4,7	5,0	5,2	5,4	5,7	
7	3,2	3,5	3,7	4,0	4,2	4,5	4,7	5,0	5,2	60
9	2,5	2,8	3,1	3,4	3,6	3,9	4,1	4,4	4,6	
5	10,9	11,3	11,7	12,1	12,5	12,9	13,3	13,7	14,1	
7	9,8	10,3	10,7	11,2	11,6	12,1	12,5	13,0	13,4	80
9	8,7	9,2	9,6	10,1	10,5	11,0	11,4	11,9	12,3	

PIPE Ø 32 x 4,4 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,8	4	4,3	4,5	4,7	5	5,2	5,4	5,7	
7	3,1	3,4	3,6	3,9	4,1	4,4	4,6	4,9	5,1	60
9	2,4	2,7	3	3,3	3,5	3,8	4	4,3	4,6	
5	11,3	11,8	12,2	12,7	13,1	13,6	14,0	14,5	14,9	
7	10,2	10,7	11,1	11,6	12,0	12,5	12,9	13,4	13,8	80
9	8,9	9,4	9,9	10,4	10,9	11,4	11,9	12,4	12,9	

PIPE Ø 40 x 5,5 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,6	3,9	4,1	4,4	4,6	4,9	5,1	5,4	5,6	
7	2,9	3,2	3,4	3,7	4,0	4,3	4,5	4,8	5,1	60
9	2,2	2,5	2,8	3,1	3,4	3,7	3,9	4,2	4,5	
5	11,5	12,0	12,4	12,9	13,4	13,9	14,3	14,8	15,3	
7	10,3	10,8	11,2	11,7	12,1	12,6	13,0	13,5	13,9	80
9	9,0	9,5	10,0	10,5	11,0	11,5	12,0	12,5	13,0	

PIPE Ø 50 x 6,9 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,5	3,8	4,0	4,3	4,5	4,8	5,1	5,3	5,6	
7	2,7	3,0	3,2	3,5	3,8	4,1	4,3	4,6	4,9	60
9	2,0	2,3	2,6	2,9	3,2	3,5	3,7	4,0	4,3	
5	11,7	12,2	12,7	13,2	13,7	14,2	14,7	15,2	15,7	
7	10,4	10,9	11,4	11,9	12,4	12,9	13,4	13,9	14,4	80
9	9,0	9,5	10,1	10,6	11,2	11,7	12,2	12,8	13,3	

PIPE Ø 63 x 8,7 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	3,2	3,5	3,8	4,0	4,3	4,6	4,9	5,2	5,4	
7	2,5	2,8	3,1	3,4	3,7	4,0	4,2	4,5	4,8	60
9	1,7	2	2,3	2,6	2,9	3,2	3,5	3,8	4,1	
5	11,8	12,3	12,8	13,3	13,8	14,3	14,8	15,3	15,8	
7	10,4	11,0	11,5	12,1	12,6	13,2	13,7	14,3	14,8	80
9	9,0	9,6	10,1	10,7	11,2	11,8	12,4	12,9	13,5	

PIPE Ø 75 x 10,4 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	2,5	2,8	3,1	3,4	3,7	3,9	4,2	4,5	4,8	
7	1,8	2,1	2,4	2,7	3,0	3,3	3,5	3,8	4,1	60
9	1,0	1,3	1,6	1,9	2,2	2,6	2,9	3,2	3,5	
5	11,4	11,9	12,4	13,0	13,5	14,0	14,5	15,0	15,6	
7	10,0	10,5	11,1	11,6	12,1	12,7	13,2	13,8	14,3	80
9	8,5	9,1	9,7	10,2	10,8	11,3	11,9	12,5	13,0	

PIPE Ø 90 x 12,5 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	2,6	2,9	3,2	3,5	3,8	4,1	4,4	4,7	5	
7	1,9	2,2	2,5	2,8	3,1	3,4	3,7	4	4,3	60
9	1,1	1,4	1,7	2,1	2,4	2,7	3	3,3	3,6	
5	11,8	12,3	12,9	13,4	13,9	14,5	15	15,6	16,1	
7	10,3	10,9	11,4	12	12,6	13,1	13,7	14,2	14,8	80
9	8,8	9,4	10	10,6	11,1	11,7	12,3	12,9	13,5	

PIPE Ø 110 x 15,2 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	2,3	2,6	2,9	3,2	3,5	3,8	4,1	4,4	4,6	
7	1,5	1,9	2,2	2,5	2,8	3,1	3,4	3,7	4	60
9	0,8	1,1	1,4	1,7	2,1	2,4	2,7	3	3,3	
5	11,5	12,2	12,8	13,4	13,9	14,5	15,1	15,6	16,2	
7	10	10,7	11,3	11,9	12,5	13,1	13,7	14,3	14,8	80
9	8,5	9,2	9,8	10,5	11,1	11,7	12,3	12,9	13,5	

PIPE Ø 125 x 17,1 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	2,2	2,5	2,8	3,1	3,4	3,7	4,0	4,3	4,5	
7	1,4	1,8	2,1	2,4	2,7	3,0	3,3	3,6	3,9	0.6
9	0,6	1,0	1,3	1,6	2,0	2,3	2,6	2,8	3,1	
5	11,3	12,0	12,6	13,2	13,7	14,3	15,0	15,5	16,0	
7	9,8	10,5	11,1	11,7	12,3	13,0	13,5	14,0	14,5	0.8
9	8,3	9,0	9,7	10,3	11,0	11,5	12,0	12,8	13,2	

PIPE Ø 160 x 21,9 SDR 7,4

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	0,8	1,1	1,4	1,7	2,0	2,3	2,6	2,9	3,2	
7	0,0	0,4	0,7	1,0	1,3	1,6	1,9	2,2	2,5	60
9	0,0	0,0	0,0	0,3	0,6	0,9	1,2	1,5	1,8	
5	10,5	11,1	11,7	12,3	12,9	13,5	14,1	14,7	15,3	
7	8,9	9,5	10,1	10,7	11,3	11,9	12,5	13,1	13,7	80
9	7,2	7,9	8,5	9,2	9,8	10,5	11,1	11,8	12,4	

PIPE Ø 200 x 18,2 SDR 11

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	1,7	2,0	2,3	2,6	2,9	3,2	3,5	3,8	4,1	
7	0,9	1,2	1,5	1,8	2,1	2,4	2,7	3,0	3,3	60
9	0,1	0,4	0,8	1,1	1,4	1,7	2,0	2,3	2,6	
5	11,5	12,2	12,8	13,5	14,1	14,7	15,3	16,0	16,6	
7	9,9	10,6	11,3	11,9	12,5	13,1	13,8	14,5	15,1	80
9	8,2	8,9	9,6	10,3	11,0	11,7	12,3	13,0	13,6	

PIPE Ø 250 x 22,7 SDR 11

Ti \ Te	26	27	28	29	30	31	32	33	34	humidity%
5	1,7	2,0	2,3	2,6	2,9	3,2	3,5	3,8	4,1	
7	0,9	1,2	1,5	1,8	2,1	2,4	2,7	3,0	3,3	60
9	0,1	0,4	0,8	1,1	1,4	1,7	2,0	2,3	2,6	
5	11,5	12,2	12,8	13,5	14,1	14,7	15,3	16,0	16,6	
7	9,9	10,6	11,3	11,9	12,5	13,1	13,8	14,5	15,1	80
9	8,2	8,9	9,6	10,3	11,0	11,7	12,3	13,0	13,6	

4.5.1 MINIMUM INSULATION THICKNESS RECOMMENDED FOR PPR PIPES

According to the current standard in force UNI EN 14114 (Hygrothermal performance of systems, buildings and industrial installations - Calculation of water vapor diffusion - Insulation systems for cold pipes), hot and cold fluid distribution networks in heat systems must be insulated with an insulating layer with thickness values as per the following table depending on:

- the diameter of the non-insulated pipe;
- the usable thermal conductivity (W/mK) of the insulation material at an average temperature of 40°C.

Diameter of the pipe	< 20 mm	from 20 to 39	from 40 to 59	from 60 to 79	from 80 to 99	> 100
Usable thermal conductivity of the insulation material W/m°C	**20**	**25 32**	**40 50**	**63 75**	**90**	**110 125 160 200 250 315 355 400 450 500 560 630**
0,030	13	19	26	33	37	40
0,032	14	21	29	36	40	44
0,034	15	23	31	39	44	48
0,036	17	25	34	43	47	52
0,038	18	28	37	46	51	56
0,040	20	30	40	50	55	60
0,042	22	32	43	54	59	64
0,044	24	35	46	58	63	69
0,046	26	38	50	62	68	74
0,048	28	41	54	66	72	79
0,050	30	44	58	71	77	84

NOTES

- For values of usable thermal conductivity of the insulation material other than those indicated in the table, the minimum thickness of the insulation material is obtained by linear interpolation of the data shown in the table.
- Vertical pipe risers shall be placed outside the thermal insulation of the building towards the inside of the building and the minimum thickness of the insulation layer resulting from the table shall be multiplied by 0,5.
- For pipes installed inside structures that do not overlook either outside or on unheated rooms, the thickness values indicated in the table shall be multiplied by 0,3.
- Hot air channels for winter heating placed in unheated spaces should be insulated with an insulation thickness not lower than the insulation thicknesses indicated in the table for pipes with an outside diameter from 20 to 39 mm.

The standard also indicates some installation requirements, in particular:
all piping shall be uniformly insulated, without chokes or reductions in thickness, ensuring the perfect welding of both the joints of the PPR system and the insulation material, insulating also elbows, fittings, flanges, valves and gate valves and everything that could be used as a thermal bridge.

4.6 HEAD LOSS

UNIT HEAD LOSS FOR PPR PIPING SYSTEM PIPES SDR 6 WITH WATER TEMPERATURE AT 10°C

Flow rate		Ø	Ø	Ø	Ø	Ø	Ø	Ø
l/s	kg/h	16x2,7	20x3,4	25x4,2	32x5,4	40x6,7	50x8,4	63x10,5
	70	10 0,22	2 0,14	0,9 0,09	Head loss in mm c.a./m Average speed in m/s			
	140	33 0,44	8 0,29	3 0,18	1 0,11			
0,05	180	52 0,57	13 0,37	4 0,23	2 0,14			
	220	73 0,70	19 0,45	6 0,28	2 0,17			
	290	118 0,92	30 0,59	10 0,37	4 0,23	1,5 0,15	0,5 0,09	
0,1	360	164 1,11	42 0,71	15 0,45	6 0,28	2 0,18	0,7 0,11	
	430	234 1,36	61 0,88	21 0,55	8 0,34	3 0,22	1,07 0,14	0,33 0,09
	510		83 1,04	29 0,66	11 0,40	4 0,26	1,44 0,16	0,45 0,10
	580		104 1,18	37 0,75	14 0,46	5 0,29	1,8 0,19	0,56 0,12
	655		129 1,34	45 0,84	18 0,52	6 0,33	2,2 0,21	0,7 0,13
0,2	730		156 1,49	55 0,94	22 0,58	7,5 0,37	2,69 0,24	0,84 0,15
	830		290 1,65	69 1,07	27 0,66	9 0,42	3,3 0,27	1 0,17
	900		353 1,83	85 1,20	33 0,74	11 0,47	4,1 0,30	1,3 0,19
0,3	1.080			110 1,39	43 0,85	15 0,54	5,3 0,35	1,6 0,22
	1.280			149 1,65	59 1,01	20 0,64	7,1 0,41	2,2 0,26
0,4	1.430			270 1,85	71 1,13	24 0,72	8 0,46	2,7 0,29
	1.605				87 1,27	30 0,81	10 0,52	3,4 0,32
0,5	1.805				107 1,43	36 0,91	13 0,58	4,2 0,36
	2.005				135 1,55	44 1,01	15 0,65	5 0,40
0,6	2.155				172 1,70	50 1,08	17 0,69	5,7 0,43
	2.330				200 1,8	57 1,17	20 0,75	6,5 0,47
0,7	2.530				225 1,98	66 1,27	23 0,82	7,6 0,51
	2.705					74 1,36	26 0,87	8,5 0,54
0,8	2.880					83 1,45	29 0,93	9,5 0,58
	3.005					89 1,51	31 0,97	10 0,61
0,9	3.255					103 1,63	36 1,05	11 0,66

Flow rate		Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
l/s	kg/h	32x5,4	40x6,7	50x8,4	63x10,5	75x10,5	90x12,5	110x15,2	125x20,8
1,0	3.600		143 1,8	43 1,16	14 0,73	7,9 0,5	2,8 0,35		
1,2	4.320		198 2,16	59 1,40	19 0,87	9,2 0,61	3,9 0,42		
1,3	4.680			66 1,49	22 0,93	10,6 0,66	4,5 0,46		
1,4	5.040			76 1,62	25 1,01	12,1 0,71	5,1 0,50		
1,6	5.760			114 1,85	32 1,16	15,3 0,81	6,4 0,57		
1,8	6.480			141 2,08	40 1,32	18,8 0,92	7,9 0,64		
2,0	7.200			170 2,31	48 1,46	22,7 1,02	9,5 0,71	3,7 0,48	
2,2	7.920				57 1,60	26,9 1,12	11,3 0,78	4,4 0,52	
2,4	8.640				66 1,74	31,4 1,22	13,1 0,85	5,1 0,57	
2,6	9.360				76 1,88	36,1 1,32	15,1 0,92	5,9 0,62	3,1 0,48
2,8	10.080				87 2,02	41,2 1,43	17,3 0,99	6,7 0,67	3,6 0,51
3,0	10.800				1113 2,17	46,6 1,53	19,5 1,06	7,5 0,71	4,1 0,55
3,5	12.600				149 2,53	61,4 1,78	25,7 1,24	9,9 0,83	5,3 0,64
4,0	14.400					77,9 2,04	32,6 1,41	12,6 0,95	6,7 0,73
4,5	16.200					96,2 2,29	40,2 1,59	15,5 1,07	8,3 0,82
5,0	18.000					116,2 2,55	48,5 1,77	18,7 1,19	10,0 0,92
6,0	21.600					161,1 3,06	67,2 2,12	25,9 1,43	13,9 1,10
7,0	25.200						88,6 2,48	34,2 1,66	18,3 1,28
8,0	28.800						112,7 2,83	43,4 1,90	23,2 1,46
9	32.400						139,3 3,18	53,6 2,14	28,7 1,65
10	36.000							64,8 2,38	34,7 1,83
11	39.600							77 2,61	41,1 2,01
12	43.200							90,0 2,85	48,1 2,20
13	46.800							104,0 3,09	55,6 2,38
15	50.400								71,9 2,75
17	54.000								92,1 3,11

UNIT HEAD LOSS FOR PPR PIPING SYSTEM PIPES SDR 7,4 WITH WATER TEMPERATURE AT 10°C

Flow rate l/s	Flow rate kg/h	Ø 25x4,2	Ø 32x4,4	Ø 40x5,5	Ø 50x6,9	Ø 63x8,7	Ø 75x10,4	Ø 90x12,5
0,10	360	16,9 0,39	5,2 0,24					
0,15	540	33,8 0,59	10,2 0,35					
0,20	720	55,4 0,79	16,7 0,47					
0,25	864	81,4 0,98	24,5 0,59					
0,30	1.080	111,6 1,18	33,6 0,71	11,7 0,45				
0,35	1.260	145,9 1,38	43,9 0,83	15,3 0,53				
0,40	1.440	184,2 1,57	55,3 0,95	19,2 0,61	6,7 0,39			
0,45	1.620	226,3 1,77	67,9 1,06	23,6 0,68	8,3 0,44			
0,50	1.800	272,2 1,96	81,5 1,18	28,3 0,76	9,9 0,49			
0,55	1.980	321,7 2,16	96,3 1,30	33,4 0,83	11,7 0,53			
0,60	2.160		112,2 1,42	38,9 0,91	13,6 0,58			
0,65	2.340		129,0 1,54	44,7 0,98	15,6 0,63	5,2 0,40		
0,70	2.520		147,0 1,66	50,9 1,06	17,8 0,68	6,0 0,43		
0,75	2.700		165,9 1,77	57,4 1,14	20,0 0,73	6,7 0,46		
0,80	2.880		185,9 1,89	64,3 1,21	22,4 0,78	7,5 0,49		
0,85	3.060		206,8 2,01	71,5 1,29	24,9 0,83	8,3 0,52		
0,90	3.240		228,7 2,13	79,1 1,36	27,6 0,87	9,2 0,55		
1,00	3.600			95,2 1,51	33,1 0,97	11,1 0,61	4,9 0,43	
1,20	4.320			131,2 1,82	45,6 1,17	15,2 0,73	6,7 0,52	
1,40	5.040			172,3 2,12	59,9 1,36	20,0 0,86	8,8 0,61	3,7 0,42
1,60	5.760				75,8 1,55	25,2 0,98	11,1 0,69	4,7 0,48
1,80	6.480				93,3 1,75	31,1 1,10	13,6 0,78	5,7 0,54
2,00	7.200				112,5 1,94	2,00 1,22	16,4 0,87	6,9 0,60
2,20	7.920				133,2 2,14	44,3 1,35	19,4 0,95	8,2 0,66
2,40	8.640					51,6 1,47	22,7 1,04	9,5 0,72
2,60	9.360					69,5 1,59	26,1 1,13	11,0 0,78

Head loss in mm c.a./m
Average speed in m/s

Flow rate l/s	Flow rate kg/h	Ø 50x6,9	Ø 63x8,7	Ø 75x10,4	Ø 90x12,5	Ø 110x15,2	Ø 125x17,1	Ø 160x21,9
2,80	10.080		67,9 1,71	29,8 1,21	12,5 0,84	4,6 0,56		
3,00	10.800		76,7 1,84	33,6 1,30	14,1 0,90	5,4 0,60	2,9 0,46	
3,50	12.600		100,9 2,14	44,2 1,52	18,6 1,05	7,1 0,70	3,8 0,54	
4,00	14.400		128,0 2,45	56,0 1,73	23,5 1,21	8,9 0,80	4,8 0,62	
4,50	16.200		158,0 2,76	69,1 1,95	29 1,36	11,0 0,90	5,9 0,69	
5,00	18.000			83,4 2,17	35 1,51	13,3 1,00	7,1 0,77	2,2 0,47
5,50	19.800			98,9 2,38	41,5 1,66	15,7 1,11	8,4 0,85	2,6 0,52
6,00	21.600			115,6 2,60	48,4 1,81	18,4 1,21	9,8 0,93	3,0 0,57
6,50	23.400				55,9 1,96	20,6 1,29	11,3 1,00	3,5 0,61
7,00	25.200				63,8 2,11	24,2 1,41	12,9 1,08	4,0 0,66
7,50	27.000				72,2 2,26	27,3 1,51	14,6 1,16	4,5 0,71
8,00	28.800				81,0 2,41	30,7 1,61	16,3 1,24	5,0 0,75
9,00	32.400				100,0 2,71	97,9 1,81	20,2 1,39	6,2 0,85
10,00	36.000					45,8 2,01	24,4 1,54	7,5 0,94
11,00	39.600					54,3 2,21	28,9 1,70	8,9 1,04
12,00	43.200					63,5 2,41	33,8 1,85	10,4 1,13
13,00	46.800					73,3 2,61	39,0 2,01	12,0 1,23
14,00	50.400						44,5 2,16	13,6 1,32
15,00	54.000						50,4 2,32	15,4 1,41
16,00	57.600						56,6 2,47	17,1 1,50
17,00	61.200						63,1 2,63	19,3 1,60
20,00	79.200							25,9 1,89
30,00	108.000							53,8 2,83
40,00	144.000							
50,00	180.000							
60,00	216.000							

UNIT HEAD LOSS FOR PPR PIPING SYSTEM PIPES SDR 11 WITH WATER TEMPERATURE AT 10°C

Flow rate l/s	Flow rate kg/h	Ø 200x18,2	Ø 250x22,7
10,00	36.000	1,46 0,48	0,50 0,30
11,00	39.600	1,73 0,52	0,59 0,33
12,00	43.200	2,02 0,57	0,69 0,36
13,00	46.800	2,33 0,62	0,80 0,40
14,00	50.400	2,65 0,67	0,91 0,43
15,00	54.000	3,00 0,71	1,03 0,46
16,00	57.600	3,37 0,76	1,16 0,49
17,00	61.200	3,75 0,81	1,29 0,52
18,00	64.800	4,16 0,86	1,43 0,55
19,00	68.400	4,58 0,90	1,57 0,58
20,00	72.000	5,02 0,95	1,72 0,95
25,00	90.000	7,49 1,19	2,56 0,76
30,00	108.000	10,40 1,43	3,56 0,91
35,00	126.000	13,73 1,66	4,69 1,06
40,00	144.000	17,47 1,90	5,97 1,22
45,00	162.000	21,61 2,14	7,38 1,37
50,00	180.000	26,14 2,38	8,92 1,52
55,00	12.600	31,07 2,62	10,60 1,67
60,00	14.400		12,40 1,82
66,00	16.200		14,74 2,01
70,00	18.000		16,39 2,13
75,00	21.600		18,58 2,28
80,00	25.200		20,88 2,43
90,00	18.000		25,86 2,74

UNIT HEAD LOSS FOR BLUE PPR FIBER GLASS PIPES SDR 11 WITH WATER TEMPERATURE AT 10°C (Ø32 TO 125)

Flow rate		Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
l/s	kg/h	20x2,8	25x3,5	32x2,9	40x3,7	50x4,6	63x5,8	75x6,8	90x8,2
0,10	360	48,4 0,61	17,0 0,39	2,9 0,19					
0,15	540	96,8 0,92	33,8 0,59	6,5 0,30					Head loss in mm c.a./m Average speed in m/s
0,20	720	159,0 1,23	55,4 0,79	9,4 0,37					
0,25	864			13,8 0,46					
0,30	1.080	321,6 1,84	111,6 1,18	18,9 0,56	6,7 0,36				
0,35	1.260			24,7 0,65	8,8 0,42				
0,40	1.440	531,8 2,46	184,3 1,57	31,1 0,74	11,1 0,48	3,8 0,31			
0,45	1.620			38,1 0,83	13,6 0,54	4,7 0,34			
0,50	1.800	787,0 3,07	272,3 1,96	45,8 0,93	16,3 0,60	5,6 0,38			
0,55	1.980			54,1 1,02	19,2 0,66	6,6 0,42			
0,60	2.160		375,0 2,36	63,0 1,11	22,3 0,72	7,7 0,46			
0,65	2.340			72,1 1,21	25,7 0,78	8,9 0,50	3,0 0,31		
0,70	2.520		492,0 2,75	82,5 1,30	29,2 0,84	10,1 0,54	3,4 0,34		
0,75	2.700			93,1 1,39	33,0 0,90	11,4 0,36	3,8 0,57		
0,80	2.880		622,7 3,14	104,2 1,48	36,9 0,96	12,7 0,61	4,3 0,39		
0,85	3.060			116,0 1,58	41,0 1,02	14,1 0,65	4,7 0,41		
0,90	3.240				43,3 1,08	15,8 0,69	5,2 0,43		
1,00	3.600				54,5 1,20	18,8 0,76	6,3 0,48	2,7 0,34	
1,20	4.320				75,2 1,44	25,8 0,92	8,6 0,58	3,7 0,41	
1,40	5.040				98,7 1,68	33,9 1,07	11,3 0,67	4,9 0,47	2,1 0,33
1,60	5.760					42,9 1,22	14,3 0,77	6,1 0,54	2,6 0,38
1,80	6.480					52,8 1,38	21,1 0,96	9,1 0,68	3,8 0,47
2,00	7.200					63,6 1,53	21,1 0,96	9,1 0,68	3,8 0,47
2,20	7.920					73,2 1,68	25,0 1,06	10,7 0,74	4,5 0,52
2,40	8.640						29,2 1,16	12,5 0,81	5,3 0,56
2,60	9.360						33,6 1,25	14,4 0,9	6,1 0,6

Flow rate		Ø	Ø	Ø	Ø	Ø	Ø
l/s	kg/h	50x4,6	63x5,8	75x6,8	90x8,2	110x10	125x11,4
2,80	10.080		38,3 1,35	16,4 0,9	6,9 0,7	2,7 0,4	
3,00	10.800		43,3 1,45	18,5 1,01	7,8 0,71	3,0 0,47	1,6 0,37
3,50	12.600		57,0 1,69	24,4 1,18	10,3 0,82	3,9 0,55	2,1 0,43
4,00	14.400		72,2 1,93	30,9 1,4	13,0 0,9	5,0 0,6	2,7 0,5
4,50	16.200			38,1 1,5	16,0 1,1	6,1 0,7	3,3 0,5
5,00	18.000			46,0 1,69	19,3 1,18	7,4 0,79	4,0 0,61
5,50	19.800			54,5 1,86	22,9 1,29	8,8 0,86	4,8 0,67
6,00	21.600			63,6 2,0	26,7 1,4	10,2 0,9	5,6 0,7
7,00	25.200				35,2 1,6	13,4 1,1	7,3 0,9
8,00	28.800				44,7 1,9	17,1 1,3	9,3 1,0
9,00	32.400					21,1 1,4	11,5 1,1
10,00	36.000					25,4 1,57	13,8 1,22
11,00	39.600					30,1 1,73	16,4 1,34
12,00	43.200					35,2 1,89	19,2 1,46
13,00	46.800					40,7 20,4	22,1 1,58
14,00	50.400						25,3 1,71
15,00	54.000						28,6 1,83
16,00	57.600						32,1 1,95
17,00	61.200						
18,00	64.800						
19,00	68.400						
20,00	72.000						
25,00	90.000						
30,00	108.000						
35,00	126.000						
40,00	144.000						

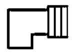
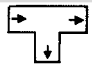
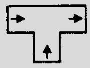
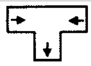
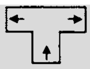
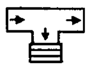
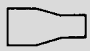
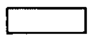
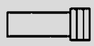
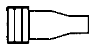
UNIT HEAD LOSS FOR BLUE PPR FIBER GLASS PIPES SDR 11 WITH WATER TEMPERATURE AT 10°C (Ø160 TO 400)

Flow rate		Ø	Ø	Ø	Ø	Ø
l/s	kg/h	160x14,6	200x18,2	250x22,7	315x28,6	400x36,3
5,00	18.000	1,2 0,37	0,4 0,24	0,1 0,15		
5,50	19.800	1,5 0,41	0,5 0,26	0,2 0,17		
6,00	21.600	1,7 0,4	0,6 0,29	0,2 0,18		
7,00	25.200	2,3 0,5	0,8 0,33	0,2 0,18		
8,00	28.800	2,9 0,6	1,0 0,38	0,3 0,21		
9,00	32.400	3,5 0,7	1,2 0,48	0,4 0,27		
10,00	36.000	4,2 0,74	1,5 0,48	0,5 0,30		
11,00	39.600	5,0 0,82	1,7 0,52	0,6 0,33		
12,00	43.200	5,9 0,89	2,0 0,57	0,7 0,36		
13,00	46.800	6,8 0,97	2,3 0,62	0,8 0,40		
14,00	50.400	7,7 1,04	2,7 0,67	0,9 0,43		
15,00	54.000	8,8 1,12	3,0 0,71	1,0 0,46		
16,00	57.600	9,8 1,19	3,4 0,76	1,2 0,49		
17,00	61.200	11,0 1,27	3,8 0,81	1,3 0,52		
18,00	64.800	12,1 1,34	4,2 0,86	1,4 0,55		
19,00	68.400	13,4 1,41	4,6 0,90	1,6 0,58		
20,00	72.000	14,7 1,49	5,0 0,95	1,7 0,61		
25,00	90.000	21,9 1,86	7,5 1,19	2,6 0,76	0,8 0,48	0,3 0,30
30,00	108.000	30,5 2,23	10,4 1,43	3,6 0,91	1,2 0,57	0,4 0,36
35,00	126.000		13,7 1,66	4,7 1,06	1,5 0,67	0,5 0,42
40,00	144.000		17,5 1,9	6,0 1,22	2,0 0,77	0,6 0,48

Flow rate		Ø	Ø	Ø	Ø	Ø
l/s	kg/h	160x14,6	200x18,2	250x22,7	315x28,6	400x36,3
45,00	162.000		21,6 2,14	7,4 1,37	2,4 0,86	0,8 0,53
50,00	180.000		26,1 2,38	8,9 1,52	2,9 0,96	0,9 0,59
55,00	198.000			10,6 1,67	3,5 1,05	1,1 0,65
60,00	216.000			12,4 1,82	4,1 1,15	1,3 0,71
66,00	237.600			14,3 1,98	4,9 1,26	1,5 0,78
70,00	252.000			16,4 2,13	5,4 1,34	1,7 0,83
75,00	270.000			18,6 2,28	6,1 1,44	1,9 0,89
80,00	288.000			20,9 2,43	6,9 1,53	2,2 0,95
90,00	324.000				8,5 1,72	2,7 1,07
100,00	360.000				10,3 1,92	3,3 1,19
110,00	396.000				12,2 2,11	3,9 1,31
120,00	432.000					4,5 1,43
130,00	468.000					5,2 1,54
140,00	504.000					6,0 1,66
150,00	540.000					6,8 1,78

4.7 FITTING HEAD LOSS (DIN 1988)

LOCAL RESISTANCE COEFFICIENTS R FOR PPR PIPING SYSTEM FITTINGS

Figure	No.	Graphic symbol	Resistance coefficient r
90° Elbow	90		2,0
Male threaded elbow	90M		2,2
45° Elbow	120		0,6
Tee Reduced Tee	130 130R		1,8 3,6
Tee union Reduced Tee	130 130R		1,3 2,6
Tee union Reduced Tee	130 130R		4,2 9
Tee union Reduced Tee	130 130R		2,2 5,0
Threaded Tee	130F		0,8
Adapter up to 2 sizes Adapter from 3 sizes	241 241		0,55 0,85
Coupler	270		0,25
Male threaded union	270M		0,4
Reduced male threaded union	270RM		0,85

The table shows the head loss z with a coefficient r = 1 for water transport at 10°C at different v flow rate values (m/s).

Flow rate v m/s	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,1	2,2	2,3	2,4	2,5
Head loss z (mbar)	0,1	0,2	0,5	0,8	1,3	1,8	2,5	3,2	4,1	5,0	6,1	7,2	8,5	9,8	11,3	12,8	14,5	16,2	18,1	20,0	22,1	24,2	26,5	28,8	31,3

Flow rate v m/s	2,6	2,7	2,8	2,9	3,0	3,1	3,2	3,3	3,4	3,5	3,6	3,7	3,8	3,9	4,0	4,1	4,2	4,3	4,4	4,5	4,6	4,7	4,8	4,9	5,0
Head loss z (mbar)	33,8	36,5	39,2	42,1	45	48	51	55	58	61	65	68	72	76	80	84	88	92	97	101	106	110	115	120	125

1 mbar = 10,1 mm c.a.

The local pressure drop z is the result of the formula z = 5v2 • ∑r and the total head loss of the system is the sum of the distributed head loss and the total of local head loss z.

4.8 SYSTEM DIMENSIONING (UNI9182)

4.8.1 HOW TO USE LOAD UNITS

The load unit is the value assumed conventionally according to the flow of a dispensing point, its characteristics and its frequency of use, used for the calculation of the maximum flow in a contemporaneous distribution of water.

1. The values indicated in the column "Cold water" shall be used to calculate the distribution of cold water.
2. The values indicated in the column "Hot water" shall be used to calculate the distributions of hot water.
3. The values indicated in the column "Total hot + cold water" shall be used to calculate the overall values of load units and the corresponding flow rate upstream of the system for the preparation of hot water.

In case of connections to single units, refer to tables D.1 and D.2.

LOAD UNITS FOR PRIVATE HOUSING

SINGLE UNITS - TABLE D.1

Unit	Supply	Load units		
		Cold water	Hot water	Total hot + cold water
Washbasin	mixer unit	0,75	0,75	1,00
Bidet	mixer unit	0,75	0,75	1,00
Bath tub	mixer unit	1,50	1,50	2,00
Shower	mixer unit	1,50	1,50	2,00
WC bowl	cistern	3,00	-	3,00
WC bowl	jet flush or flow meter	6,00	-	6,00
Kitchen sink	mixer unit	1,50	1,50	2,00
Washing machine	cold water only	2,00	-	2,00
Dishwasher	cold water only	2,00	-	2,00
Washer	mixer unit	1,50	1,50	2,00
ø 3/8" hydrant	cold water only	1,00	-	1,00
ø ½" hydrant	cold water only	2,00	-	2,00
ø ¾" hydrant	cold water only	3,00	-	3,00
ø 1" hydrant	cold water only	6,00	-	6,00

LOAD UNITS FOR PUBLIC AND COLLECTIVE BUILDINGS (HOTELS, OFFICES, HOSPITALS ETC.)

SINGLE UNITS - TABLE D.2

Unit	Supply	Load units		
		Cold water	Hot water	Total hot + cold water
Washbasin	mixer unit	1,50	1,50	2,00
Bidet	mixer unit	1,50	1,50	2,00
Bath tub	mixer unit	3,00	3,00	4,00
Shower	mixer unit	3,00	3,00	4,00
WC bowl	cistern	5,00	-	5,00
WC bowl	jet flush or flow meter	10,00	-	10,00
Urinal	urinal tap	0,75	-	0,75
Urinal	jet flush or flow meter	10,00	-	10,00
Sink	mixer unit	2,00	2,00	3,00
Kitchen washtub	mixer unit	3,00	3,00	4,00
Washer	mixer unit	2,00	2,00	3,00
Slop sink	cistern	5,00	-	5,00
Slop sink	jet flush or flow meter	10,00	-	10,00
Washing-through washbasin (for each position)	mixer unit	1,50	1,50	2,00
Feet-pool	mixer unit	1,50	1,50	2,00
Bedpan washer	mixer unit	2,00	2,00	3,00
Medical washbasin	mixer unit	1,50	1,50	2,00
Drinking fountain	spring tap	0,75	-	0,75
Emergency shower	pressure control	3,00	-	3,00
ø 3/8" hydrant	cold water only	2,00	-	2,00
ø ½" hydrant	cold water only	4,00	-	4,00
ø ¾" hydrant	cold water only	6,00	-	6,00
ø 1" hydrant	cold water only	10,00	-	10,00

INFORMATION APPENDIX – NOMINAL FLOW AND PRESSURE RATES OF DELIVERY TAPS FOR SANITARY WARE AND OTHER USES

The flow rates indicated in table C.1 are intended as minimum. For correct sizing, to ensure the efficient functioning of the device, use the values indicated by the manufacturer. To maintain water quality under an hygienic point of view, it is necessary to avoid unnecessary over-sizing of the pipes.

Unit	Flow rate l/s *	Minimum pressure kPa
Washbasin	0,10	100
Bidet	0,10	100
WC bowl	0,10	100
WC bowl with jet flush or flow meter	1,00	100
Bath tub	0,30	100
Shower	0,15	100
Kitchen sink	0,15	100
Washing machine	0,15	100
Urinal	0,15	100
Hydrant/garden tap	0,40	100

* Calculated at a pressure of 3 bar

The maximum allowable speed circuits [1)] are as follows:
- primary distribution, risers, piping distribution at the floor: max 2,0 m/s;
- supply line to the single unit: max 4,0 m/s.

[(1)] Values of speed as per UNI EN 806-3

DETERMINATION OF THE MAXIMUM SIMULTANEOUS FLOW BY THE METHOD OF LOAD UNITS, HOT AND COLD WATER

UNITS IN PRIVATE HOMES AND COLLECTIVE BUILDINGS (HOTELS, HOSPITALS, SCHOOLS, BARRACKS, SPORTS CENTRES AND THE LIKE)

TABLE D.3 - WC BOWLS WITH CISTERNS

Load Unit	Flow l/s	Load Unit	Flow l/s	Load Unit	Flow l/s
6	0,30	120	3,65	1.250	15,50
8	0,40	140	3,90	1.500	17,50
10	0,50	160	4,25	1.750	18,80
12	0,60	180	4,60	2.000	20,50
14	0,68	200	4,95	2.250	22,00
16	0,78	225	5,35	2.500	23,50
18	0,85	250	5,75	2.750	24,50
20	0,93	275	6,10	3.000	26,00
25	1,13	300	6,45	3.500	28,00
30	1,30	400	7,80	4.000	30,50
35	1,46	500	9,00	4.500	32,50
40	1,62	600	10,00	5.000	34,50
50	1,90	700	11,00	6.000	38,00
60	2,20	800	11,90	7.000	41,00
70	2,40	900	12,90	8.000	44,00
80	2,65	1.000	13,80	9.000	47,00
90	2,90			10.000	50,00
100	3,15				

TABLE D.4 - WC BOWLS WITH JET FLUSH OR FLOW METER

Load Unit	Flow l/s	Load Unit	Flow l/s	Load Unit	Flow l/s
10	1,70	120	7,15	1.250	21,00
12	1,90	140	7,50	1.500	23,00
14	2,10	160	8,00	1.750	24,50
16	2,27	180	8,50	2.000	26,00
18	2,45	200	9,00	2.250	27,50
20	2,60	225	9,50	2.500	28,50
25	2,95	250	10,00	2.750	29,50
30	3,25	275	10,50	3.000	30,50
35	3,55	300	11,00	3.500	33,00
40	3,80	400	12,70	4.000	35,00
50	4,30	500	14,00	4.500	36,50
60	4,80	600	15,10	5.000	37,50
70	5,25	700	16,30	6.000	40,50
80	5,60	800	17,30	7.000	44,00
90	6,00	900	18,20	8.000	46,00
100	6,35	1.000	19,00	9.000	48,00
				10.000	50,00

UNITS IN OFFICE BUILDINGS AND THE LIKE

TABLE D.5 - WC BOWLS WITH CISTERNS

Load Unit	Flow l/s	Load Unit	Flow l/s	Load Unit	Flow l/s
6	0,30	120	2,90	1.250	11,30
8	0,40	140	3,20	1.500	12,40
10	0,50	160	3,50	1.750	13,60
12	0,60	180	3,75	2.000	14,50
14	0,67	200	3,95	2.250	15,40
16	0,75	225	4,25	2.500	16,20
18	0,82	250	4,50	2.750	17,00
20	0,89	275	4,80	3.000	18,00
25	1,05	300	5,05	3.500	19,50
30	1,18	400	6,00	4.000	21,00
35	1,35	500	6,90	4.500	22,00
40	1,45	600	7,55	5.000	23,50
50	1,65	700	8,30	6.000	25,50
60	1,90	800	8,80	7.000	27,50
70	2,10	900	9,50	8.000	29,00
80	2,25	1.000	10,00	9.000	30,50
90	2,45			10.000	32,00
100	2,60				

TABLE D.6 - WC BOWLS WITH JET FLUSH OR FLOW METER

Load Unit	Flow l/s	Load Unit	Flow l/s	Load Unit	Flow l/s
10	1,70	120	5,80	1.250	15,50
12	1,87	140	6,20	1.500	16,50
14	2,03	160	6,60	1.750	17,50
16	2,17	180	7,10	2.000	18,50
18	2,32	200	7,45	2.250	19,20
20	2,45	225	7,80	2.500	20,00
25	2,75	250	8,10	2.750	20,70
30	3,00	275	8,40	3.000	21,40
35	3,25	300	8,70	3.500	22,50
40	3,55	400	9,80	4.000	24,00
50	3,90	500	10,80	4.500	25,00
60	4,20	600	11,60	5.000	26,20
70	4,50	700	12,40	6.000	28,00
80	4,80	800	13,00	7.000	29,00
90	5,15	900	13,70	8.000	30,00
100	5,35	1.000	14,20	9.000	31,50
				10.000	32,00

4.9 HOT SANITARY WATER SUPPLY

To correctly dimension a central hot sanitary water supply system according to Standard UNI 9182, it is necessary to calculate the maximum simultaneous hourly consumption of **hot water at 40°C** using the following formula:

$$Qmax = \left[\frac{q1 \times N1}{d1} + \frac{q2 \times N2}{d2} + \frac{qn \times Nn}{dn} \right] \times f1 \times f2 \times f3$$

where:

Qmax = Simultaneous max. hourly consumption (l/h)
q1, q2, qn = Consumption for each reference unit (accommodation unit, apartment, users) (l)
N1, N2, Nn = Number of reference units corresponding to consumptions q1, q2...qn
d1, d2, dn = Duration corresponding to consumption q1 N1, q2 N2 ... qn Nn (h) just for houses
f1 = Factor for number of accommodation units
f2 = Factor for number of rooms in each accommodation unit
f3 = Factor for standard of living

q = Average daily requirements per person

TABLE E.1 - HOT WATER: DEMAND PER PERSON

Building type	q = Liters per person / day
Houses *	
a) standard house	from 40 to 50
b) average house	from 70 to 80
c) luxury house	from 150 to 200
Hotels and small hotels	
a) rooms with private bathroom including bath tub	from 180 to 200
b) rooms with private bathroom including shower	130
c) rooms with washbasin and bidet	60
Offices	from 15 to 200
Hospitals and health care facilities	from 130 to 150
Sports centres	from 50 to 60
Changing rooms	from 30 to 50

* The values indicated shall be multiplied by the correction factors indicated in the following tables to take into account the number of homes, the size of each home and the living standard of the user.

N = Average daily requirements per use

TABLE E.2 - HOT WATER: DEMAND PER UNIT AT EVERY USE

Unit	N = l
Bath tub 170 cm x 70 cm with hand shower	from 160 to 200
Bath tub 105 cm x 70 cm	from 100 to 120
Shower	from 50 to 60
Washbasin	from 10 to 12
Bidet	from 8 to 10
Kitchen sink	from 15 to 20

d = Duration of peak time

TABLE F.1 - DURATION OF THE PERIOD OF PEAK CONSUMPTION OF HOT WATER

Housing type	d = duration of peak time h
Houses a) with up to 4 rooms b) with more than 4 rooms	 from 2 to 2,5 3
Hotels and small hotels* a) rooms with private bathroom including bath tub or shower b) rooms with washbasin and bidet	 from 2,5 to 3 from 3 to 4
Offices	1
Hospitals and health care facilities	from 3 to 4
Sports centres**	1
Changing rooms**	1

* Except hotels designed to receive large groups for which the duration can decrease from 1 h to 1,5 h

** The durations indicated are to be referred to the consumption corresponding to the actual number of users

f1 – Multiplying factor of hot water supply in liters/person-day according to the NUMBER OF ACCOMODATION UNITS

Number of accomodation units	Multiplying factor
1	1,15
2	0,86
3	0,73
4	0,65
5	0,60
6	0,56
7	0,53
8	0,50
9	0,48
10	0,47
11	0,46
12	0,35
13	0,44
14	0,44
15	0,43
16	0,43
17	0,42
18	0,42
19	0,41
20	0,41
21	0,40
22	0,40
23	0,39
24	0,39
25	0,38
from 26 to 30	0,36
from 31 to 35	0,35
from 36 to 40	0,34
from 41 to 45	0,33
from 51 to 60	0,31
from 61 to 70	0,30
from 71 to 80	0,29
from 81 to 90	0,29
from 91 to 100	0,28
from 101 to 125	0,27
from 126 to 150	0,26
from 151 to 200	0,25
from 201 to 300	0,24
from 301 to 400	0,23

f2 – Multiplying factor of hot water supply in liters/person-day according to the NUMBER OF ROOMS

Number of rooms	Multiplying factor
1	0,8
2	0,9
from 3 to 4	1
from 5 to 6	1,1
from 7 to 8	1,2
from 9 to 10	1,3
from 10 to 12	1,4
more than 12	1,5

f3 – Multiplying factor of hot water supply in liters/person-day according to the STANDARD OF LIVING

Standard of living	Multiplying factor
Low	0,8
Moderate	0,9
Standard	1,0
Good	1,1
High	1,2

Calculation of the maximum simultaneous flow rate according to the load unit method, cold water and hot water (WC bowls with cisterns - to be considered only for cold water) for private housing and collective building units.

PPR PIPING SYSTEM RISERS WITH SDR 6 PIPES (MAX VELOCITY CONSIDERED 2,5 M/S)

UC Load unit	Maximum simultaneous flow rate l/s	PPR PIPING SYSTEM pipe SDR 6
6	0,30	20
8	0,40	25
10	0,50	
12	0,60	32
14	0,68	
16	0,78	
18	0,85	
20	0,93	40
25	1,13	
30	1,30	
35	1,46	50
40	1,62	
50	1,90	
60	2,20	63
70	2,40	
80	2,65	
90	2,90	
100	3,15	
120	3,65	75
140	3,90	
160	4,25	
180	4,60	
200	4,95	
225	5,35	90
250	5,75	
275	6,10	
300	6,45	
400	7,8	110
500	9,00	
600	10,00	125
700	11,00	
800	11,90	
900	12,90	
1000	13,80	

PPR PIPING SYSTEM RISERS WITH SDR 7.4 PIPES (MAX VELOCITY CONSIDERED 2,5 M/S)

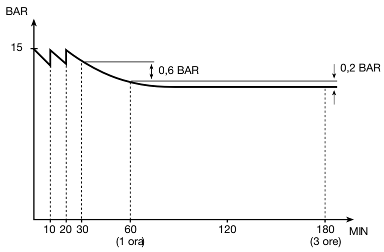
UC Load unit	Maximum simultaneous flow rate l/s	PPR PIPING SYSTEM pipe SDR 7,4
6	0,30	20
8	0,40	25
10	0,50	
12	0,60	
14	0,68	32
16	0,78	
18	0,85	
20	0,93	
25	1,13	40
30	1,30	
35	1,46	
40	1,62	50
50	1,90	
60	2,20	
70	2,40	
80	2,65	63
90	2,90	
100	3,15	
120	3,65	
140	3,90	
160	4,25	75
180	4,60	
200	4,95	
225	5,35	
250	5,75	90
275	6,10	
300	6,45	
400	7,80	
500	9,00	110
600	10,00	
700	11,00	
800	11,90	
900	12,90	125
1000	13,80	
1500	17,50	160
1750	18,80	
2000	20,50	
2250	22,00	
2500	23,50	
3000	26,00	

This table shows that a Ø 90 SDR 7.4 pipe can simultaneously supply 250 load units (250 / 7 = 35 apartments with bathroom and kitchen).

4.10 SYSTEM TESTING

The testing of the water supply system is carried out through **tests and checks during the installation** (for the parts that are no longer accessible once the work is completed) and **tests and final checks** for the implementation of contractual obligations.

The cold hydraulic test pressure prescribed by European standards CEN TR 12108 and EN 806-4 (Procedure C) is carried out according to the following procedure.



1 Fill the system slowly to vent it (do not fully tighten the highest plugs that will be closed when the water will come out with a continuous jet).

2 Bring the pressure up to 15 bar and repeat the process 2 more times every 10 minutes.

3 Measure the pressure after the first 30 minutes.

4 Read the pressure after another 30 minutes (1 hour). If the difference is less than 0,6 bar, there is no pressure drop and the test can be continued with the same pressure for 2 more hours.

5 In these last 2 hours the pressure must not drop more than 0,2 bar.

6 The results of this test shall be recorded.

N.B.:
Testing pressure shall be reduced if radiators, taps or valves are present.

IT IS ALSO IMPORTANT TO PERFORM:

- Cold water supply test with cold water bleed from all utilities to check the flow rate and pressure.
- Hot water supply test with hot water bleed from all utilities to check the flow rate and pressure.
- Noise level check in accordance with the regulations in force.

4.11 CHEMICAL COMPATIBILITY OF PPR

This chart shows the chemical resistance of polypropylene resin under static conditions and not under pressure.
Note: the user is advised to carry out his/her own tests to determine the suitability of polypropylene in a particular environment

A = Negligible effect
The material should be suitable for all applications where these environmental conditions exist.

B = Limited absorption or attack
The material should be suitable for most applications but the user is advised to carry out his/her own tests to determine the suitability of polypropylene in a particular environment.

C = Extensive absorption and/or rapid permeation
The material should be suitable for applications where only intermittent service is involved, or where the swelling produced has no detrimental effect on the part. The user should carry out his/her own tests to determine the suitability of polypropylene in a particular environment.

D = Extensive attack
The specimen dissolves or disintegrates. Polypropylene is not recommended.

Environment	Conc. %	Temp.		
		20°C	60°C	100°C
Acetic acid (glacial)	97	A	B (80°C)	-
Acetic acid	50	A	A (80°C)	-
Acetic acid	40	A	-	-
Acetic acid	10	A	A	-
Acetone	100	A	A	-
Acetophenone	100	B	B	-
Acriflavine (2% solution in H_2O)	2	A	A	- (80°C)
Acrylic emulsions		A	A	-
Aluminum chloride		A	A	-
Aluminum fluoride		A	A	-
Aluminum sulfate		A	A	-
Alums (all types)		A	A	-
Ammonia (aqueous)	30	A	-	-
Ammonia gas (dry)		A	A	-
Ammonium carbonate	Satd.	A	A	-
Ammonium chloride	Satd.	A	A	-
Ammonium fluoride	20	A	A	-
Ammonium hydroxide	10	A	A	-
Ammonium metaphosphate	Satd.	A	A	-
Ammonium nitrate	Satd.	A	A	-
Ammonium persulfate	Satd.	A	A	-
Ammonium sulfate	Satd.	A	A	-
Ammonium sulfide	Satd.	A	A	-
Ammonium thiocyanate	Satd.	A	A	-
Amyl acetate	100	B	C	-
Amyl alcohol	100	A	B	-
Amyl chloride	100	C	C	-
Aniline	100	A	A	-
Anisole	100	B	B	-
Antimony chloride		A	A	-
Aviation fuel (115/145 octane)	100	B	C	-
Aviation turbine fuel	100	B	C	-

(a) May produce cracking in material under stress

Environment	Conc. %	Temp.		
		20°C	60°C	100°C
Barium carbonate	Satd.	A	A	-
Barium chloride	Satd.	A	A	-
Barium hydroxide		A	A	-
Barium sulfate	Satd.	A	A	-
Barium sulfide	Satd.	A	A	-
Beer		A	A	-
Benzene	100	B	C	C
Benzoic acid	A	A	-	
Benzyl alcohol		A	A (80°C)	-
Bismuth carbonate	Satd.	A	A	-
Borax		A	A	-
Boric acid		A	A	-
Brine	Satd.	A	A	-
Bromine liquid	100	D	-	-
Bromine water	(a)	C	-	-
Butyl acetate	100	C	C	-
Butyl alcohol	100	A	A	-
Calcium carbonate	Satd.	A	A	-
Calcium chlorate	Satd.	A	A	-
Calcium chloride	50	A	A	-
Calcium hydroxide		A	A	-
Calcium hypochlorite bleach	20(a)	A	B	-
Calcium nitrate		A	A	-
Calcium phosphate	50	A	-	-
Calcium sulfate		A	A	-
Calcium sulfite		A	A	-
Carbon dioxide (dry)		A	A	-
Carbon dioxide (wet)		A	A	-
Carbon disulfide	100	B	C	-
Carbon monoxide		A	A	-
Carbon tetrachloride	100	C	C	C
Carbonic acid		A	A	-
Castor oil		A	-	-

Environment	Conc. %	Temp. 20°C	60°C	100°C
Cetyl alcohol	100	A	-	-
Chlorine (gas)	100	D	D	-
Chlorobenzene	100	C	C	-
Chloroform	100	C	D	D
Chlorosulfonic acid	100	D	D	D
Chrome alum		A	A	-
Chromic acid	80(a)	A	-	-
Chromic acid	50(a)	A	A	-
Chromic acid	10(a)	A	A	-
Chromic/sulfuric acid		D	D	-
Cider		A	A	-
Citric acid	10	A	A	-
Copper chloride	Satd.	A	A	-
Copper cyanide	Satd.	A	A	-
Copper fluoride	Satd.	A	A	-
Copper nitrate	Satd.	A	A	-
Copper sulfate	Satd.	A	A	-
Cottonseed oil		A	A	-
Cuprous chloride	Satd.	A	A	-
Cyclohexanol	100	A	B	-
Cyclohexanone	100	B	C	-
Decalin	100	C	C	C
Detergents	2	A	A	A
Developers (photographic)		A	A	-
Dibutyl phthalate	100	A	B	D
Dichloroethylene	100	A	-	-
Diethanolamine	100	A	A	-
Diisooctyl phthalate	100	A	A	-
Emulsifiers		A	A	-
Ethanolamine	100	A	A	-
Ethyl acetate	100	B	B	-
Ethyl alcohol	96	A	A (80°C)	-
Ethyl chloride	100	C	C	-
Ethylene dichloride	100	B	-	-
Ethylene glycol		A	A	-
Ethylene oxide	100	B (10°C)	-	-
Ethyl ether	100	B	-	-
Fatty acids (C_6)	100	A	A	-
Ferric chloride	Satd.	A	A	-
Ferric nitrate	Satd.	A	A	-
Ferric sulfate	Satd.	A	A	-
Ferrous chloride	Satd.	A	A	-
Ferrous sulfate	Satd.	A	A	-
Fluorosilicic acid		A	A	-
Formaldehyde	40	A	A	-
Formic acid	100	A	-	-
Formic acid	10	A	A	-
Fructose		A	A	-
Fruit juices		A	A	-
Furfural	100	C	C	-
Gas liquor		C	-	-
Gasoline	100	B	C	C
Gearbox oil	100	A	B	-
Gelatin		A	A	-

(a) May produce cracking in material under stress

Environment	Conc. %	Temp. 20°C	60°C	100°C
Glucose	20	A	A	-
Glycerin	100	A	A	A
Glycol		A	A	-
Hexane	100	A	B	-
Hydrobromic acid	50(a)	A	A	-
Hydrobromic acid	30(a)	A	B	D
Hydrobromic acid	20	A	A (80°C)	-
Hydrobromic acid	10	A	A (80°C)	B
Hydrobromic acid	2	A	A	A
50-50 HCl-HNO_3	(a)	B	D (80°C)	-
Hydrofluoric acid	40	A	-	-
Hydrofluoric acid	60(a)	A	A (40°C)	-
Hydrogen chloride gas (dry)	100	A	A	-
Hydrogen peroxide	30	A	-	D
Hydrogen peroxide	10	A	B	-
Hydrogen peroxide	3	A	-	-
Hydrogen sulfide		A	A	-
Hydroquinone		A	A	-
Inks		A	A	-
Iodine tincture		A	-	-
Isooctane	100	C	C	-
Isopropyl alcohol	100	A	A	-
Ketones		A	-	-
Lactic acid	20	A	A	-
Lanolin	100	A	A	-
Lead acetate	Satd.	A	A	-
Linseed oil	100	A	A	-
Lubricating oil	100	A	B	-
Magenta dye (aqueous solution)	2	A	A Some staining	-
Magnesium carbonate	Satd.	A	A	-
Magnesium chloride	Satd.	A	A	-
Magnesium hydroxide	Satd.	A	A	-
Magnesium nitrate	Satd.	A	A	-
Magnesium sulfate	Satd.	A	A	-
Magnesium sulfite	Satd.	A	A	-
Meat juices		A	A	-
Mercuric chloride	40	A	A	-
Mercuric cyanide	Satd.	A	A	-
Mercurous nitrate	Satd.	A	A	-
Mercury	100	A	A	-
Methyl alcohol	100	A	A	-
Methylene chloride	100	A	-	-
Methyl ethyl ketone	100	A	B	-
Milk and its products		A	A	A
Mineral oil	100	A	B	-
Molasses		A	A	-
Motor oil	100	A	B	-
Naphthalene	100	A	A	A
Nickel chloride	Satd.	A	A	-

Environment	Conc. %	Temp. 20℃	60℃	100℃
Nickel nitrate	Satd.	A	A	-
Nickel sulfate	Satd.	A	A	-
Nitric acid	fuming	D	D	D
Nitric acid	70(a)	C	D	-
Nitric acid	60	A	D (80°C)	-
Nitric acid	10	A	A	A
50-50 HNO_3-HCl	(a)	B	D (80°C)	-
50-50 HNO_3-H_2SO_4	(a)	C	D (80°C)	-
Nitrobenzene	100	A	A	-
Oleic acid		A	B	-
Oleum		-	-	D
Olive oil	100	A	A	-
Oxalic acid (aqueous)	50	A	B	-
Paraffin	100	A	B	-
Paraffin wax	100	A	A	-
Petrol	100	B	C	-
Petroleum ether (boiling point 100°-140°C)	100	C	C	-
Phenol	100	A	A	-
Phosphoric acid	95	A	A	-
Plating solutions, brass		A	A	-
Plating solutions, cadmium		A	A	-
Plating solutions, chromium		A	A	-
Plating solutions, copper		A	A	-
Plating solutions, gold		A	A	-
Plating solutions, indium		A	A	-
Plating solutions, lead		A	A	-
Plating solutions, nickel		A	A	-
Plating solutions, rhodium		A	A	-
Plating solutions, silver		A	A	-
Plating solutions, tin		A	A	-
Plating solutions, zinc		A	A	-
Potassium bicarbonate	Satd.	A	A	-
Potassium borate	1	A	A	-
Potassium bromate	10	A	A	-
Potassium bromide	Satd.	A	A	-
Potassium carbonate	Satd.	A	A	-
Potassium chlorate	Satd.	A	A	-
Potassium chloride	Satd.	A	A	-
Potassium chromate	40	A	A	-
Potassium cyanide	Satd.	A	A	-
Potassium dichromate	40	A	A	-
Potassium ferri-/ferrocyanide		A	A	-
Potassium fluoride		A	A	-
Potassium hydroxide	50	A	A	-
Potassium hydroxide	10	A	A	A
Potassium nitrate	Satd.	A	A	-
Potassium perborate	Satd.	A	A	-
Potassium perchlorate	10	A	A	-
Potassium permanganate	20	A	A	-
Potassium sulfate		A	A	-
Potassium sulfide		A	A	-
Potassium sulfite		A	A	-
Propyl alcohol	100	A	A	-
Pyridine	100	A	-	-

(a) May produce cracking in material under stress

Environment	Conc. %	Temp. 20℃	60℃	100℃
Silicone oil	100	A	A	-
Soap solution (concentrated)		A	A	-
Sodium acetate		A	A	-
Sodium bicarbonate	Satd.	A	A	-
Sodium bisulfate	Satd.	A	A	-
Sodium bisulfite	Satd.	A	A	-
Sodium borate		A	A	-
Sodium bromide oil solution		A	A	-
Sodium carbonate	Satd.	A	A	-
Sodium chlorate	Satd.	A	A	-
Sodium chloride	Satd.	A	A	A
Sodium chlorite	2	A	A (80°C)	-
Sodium chlorite	5	A (80°C)	A	-
Sodium chlorite	10	A (80°C)	A	-
Sodium chlorite	20	A (80°C)	A	-
Sodium cyanide	Satd.	A	A	-
Sodium dichromate	Satd.	A	A	-
Sodium ferricyanide	Satd.	A	A	-
Sodium ferrocyanicle	Satd.	A	A	-
Sodium fluoride	Satd.	A	A	-
Sodium hydroxide	50	A	A	-
Sodium hydroxide	10	A	A	A
Sodium hypochlorite	20	A	B	B
Sodium nitrate		A	A	-
Sodium nitrite		A	A	-
Sodium silicate		A	A	-
Sodium sulfate	Satd.	A	A	-
Sodium sulfide	25	A	A	-
Sodium sulfite	Satd.	A	A	-
Stannic chloride	Satd.	A	A	-
Stannous chloride	Satd.	A	A	-
Starch		A	A	-
Sugars and syrups		A	A	-
Sulfamic acid		A	A (80°C)	-
Sulfates of Calcium and magnesium	Satd.	A	A	-
Sulfates of potassium and sodium		A	A	-
Sulfur		A	A	-
Sulfuric acid	98(a)	C	-	D
Sulfuric acid	60	A	B (80°C)	-
Sulfuric acid	50	A	B	-
Sulfuric acid	10	A	A	A
50-50 H_2SO_4/HNO_3	(a)	C	D (80°C)	-
Tallow		A	A	-
Tannic acid	10	A	A	-
Tartaric acid		A	A	-
Tetrahydrofuran	100	C	C	C
Tetralin	100	C	C	C
Toluene	100	C	C	-
Transformer oil	100	A	C	-
Trichloroacetic acid	10	A	A	-
Trichloroethylene	100	A	A (80°C)	-
Turpentine	100	C	C	C

Environment	Conc. %	Temp. 20°C	60°C	100°C
Urea		A	A	-
Urine		A	A	-
Water (distilled, soft, hard and vapor)		A	A	A
Wet chlorine gas		-	D (70°C)	-
Whiskey		A	A	A
White Paraffin	100	A	B (80°C)	-
White spirit	100	B	C	-
Wines		A	A	-
Xylene	100	C	C	C
Yeast		A	A	-
Zinc chloride	Satd.	A	A	-
Zinc oxide		A	A	-
Zinc sulfate	Satd.	A	A	-

4.11.1 CHEMICAL COMPATIBILITY OF PLASTICS AND METALS

For all non-metals
R = Resistant
A = Excellent – no effect
B = Good – minor effect
C = Fair – moderate effect
U = Unsatisfactory
X = Conflicting data
- = No data available

For metals
E <2 mil Penetration/Year
G <20 mil Penetration/Year
S <50 mil Penetration/Year
U >50 mil Penetration/Year (1 mil = .001 inch)
A = Excellent – no effect *
B = Good – minor effect *
C = Fair – moderate effect *

* No corrosion rate reported

	Plastics											Elastopolymer										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon®)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon®	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Acetaldehyde	U	A	U	R	U	U	A	A	U	U	X	A	A	C	U	U	A	U	U	–	R	E	E	G	E	G	U	U
Acetamide	–	A	–	R	R	R	A	A	U	–	C	A	A	B	A	U	B	U	B	–	–	G	G	–	–	G	–	–
Acetate Solvent	U	–	U	R	R	R	B	A	U	U	A	A	A	C	U	–	A	U	U	–	–	E	E	G	E	E	S	G
Acetic Acid 10%	X	X	C	R	U	R	B	A	U	–	C	A	A	C	C	–	C	U	R	A	R	E	E	U	E	G	U	G
Acetic Acid, Glacial	U	U	U	R	U	R	A	A	U	U	B	U	A	X	X	U	B	U	U	A	R	E	E	U	E	E	U	U
Acetone	U	A	U	R	R	R	A	A	U	U	U	A	A	U	U	U	B	U	U	A	R	E	E	G	E	E	G	E
Acetonitrile	U	–	–	R	R	–	R	R	–	–	R	R	–	–	–	–	–	–	–	–	–	G	G	G	–	E	G	G
Acetophenone	U	–	–	R	R	U	R	R	U	U	R	R	–	U	U	–	–	–	U	–	–	G	G	G	G	G	G	G
Acetyl Chloride	U	–	U	R	U	U	U	A	U	U	R	U	–	U	U	U	–	–	R	–	R	G	G	G	–	U	U	U
Acetylene	R	–	R	R	R	–	R	R	R	R	R	R	–	R	R	–	–	–	R	–	–	E	E	G	G	E	U	U
Acrylonitrile	U	–	X	R	R	R	A	A	X	U	A	X	–	C	U	–	U	–	U	–	–	G	G	G	G	E	G	G
Adipic Acid	R	–	A	R	–	R	B	A	R	R	A	A	A	B	X	–	U	–	X	–	–	G	G	G	E	G	–	G
Aldrin (1 oz./gal.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	E	E	G	–	E	–	–
Allyl Alcohol	U	–	R	R	R	R	R	R	R	R	R	R	–	R	R	–	–	–	R	–	–	E	E	G	G	G	G	E
Allyl Chloride	U	–	U	R	–	R	R	R	U	U	R	U	–	U	U	–	–	–	–	–	R	G	E	U	–	U	–	–
Ammonium Acetate	–	–	A	R	A	–	A	A	R	R	R	A	–	A	B	–	–	A	A	–	–	G	G	–	–	G	U	U
Ammonium Oxalate 10%	–	–	–	R	–	–	R	R	R	–	–	R	–	–	–	–	–	–	–	–	–	G	G	U	E	E	–	U
Amyl Acetate	U	B	U	R	R	R	X	A	U	U	A	A	A	U	U	U	U	U	U	A	R	E	E	G	E	E	E	G
Amyl Alcohol	R	A	A	R	A	R	B	A	R	U	A	A	A	A	B	U	U	A	B	A	R	G	G	G	G	G	G	G
Amyl Chloride	U	–	U	R	U	U	U	R	U	U	U	R	–	U	U	–	–	–	R	–	–	G	G	U	E	U	G	G
Aniline	U	A	X	R	X	R	X	A	U	U	A	X	A	U	U	U	U	C	B	A	R	E	E	G	G	G	U	U
Aniline Hydrochloride	U	–	U	R	U	U	X	A	X	U	A	B	–	U	U	–	U	U	A	–	R	U	U	U	U	U	U	G
Antifreeze	B	U	A	–	U	–	U	–	A	–	–	A	–	C	A	–	C	B	A	–	–	–	A	–	–	A	–	–
Aroclor 1248	–	–	–	R	A	U	U	A	–	–	–	B	A	U	X	–	B	–	A	–	–	G	G	G	E	E	E	E
Asphalt	–	B	X	R	A	R	B	A	A	–	A	U	A	U	X	–	U	–	A	–	–	G	G	G	–	E	E	E
Benzaldehyde	X	A	U	R	A	U	X	A	U	U	A	A	A	U	U	U	U	U	U	A	R	G	G	U	G	G	G	G
Benzene	U	A	U	R	A	U	X	A	U	U	A	U	B	U	U	U	U	C	A	A	R	G	G	G	G	E	G	G
Benzo Sulfonic Acid 10%	R	–	R	R	U	R	R	R	R	R	R	U	–	R	U	U	–	–	R	–	R	G	G	U	G	U	G	–
Benzyl Alcohol	U	A	X	R	B	U	A	A	U	U	A	B	A	X	X	U	–	U	A	A	R	E	E	G	G	G	G	E
Benzoic Acid	R	B	A	R	X	B	R	A	R	R	A	U	A	B	U	U	B	A	A	A	R	G	G	U	E	G	G	G
Benzol	U	A	U	R	X	U	U	A	U	U	A	U	A	U	U	U	U	C	A	A	R	G	G	G	G	E	G	G
Benzonitrile	–	–	–	R	R	A	–	A	–	–	–	–	A	–	–	–	A	–	–	–	–	U	U	–	C	–	–	–
Benzyl Chloride	U	A	U	R	R	–	C	R	R	–	R	U	–	U	U	–	U	–	A	–	–	G	G	U	–	U	U	U
Bromobenzene	–	–	–	R	–	–	U	R	–	–	R	U	–	U	U	–	–	–	R	–	–	–	–	–	–	–	–	–
Butadiene	U	A	A	R	R	U	U	A	R	U	A	X	A	B	X	U	U	–	B	–	–	G	G	G	G	G	G	G

	Plastics											Elastopolymer										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon®)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel–F	Neoprene	Nitrile Buna–N	Polyurethane	Silicone	Tygon®	Viton–A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy–C	Aluminum	Brass	Copper
Butane	B	A	C	R	R	U	U	A	R	R	A	U	A	A	A	R	U	C	A	–	–	G	G	E	G	G	G	G
Butyl Alcohol	U	A	A	R	B	B	R	A	R	U	A	A	A	A	X	–	B	B	A	–	R	E	E	G	G	E	G	G
n-Butyl Amine	–	X	U	R	R	U	U	A	U	U	X	–	U	U	R	–	B	U	U	–	–	–	G	G	G	G	–	–
Butyl Ether	–	U	U	R	A	–	–	A	R	–	A	U	A	U	B	–	U	A	U	–	–	–	E	E	–	E	–	–
Butyl Phenol	U	–	U	R	–	–	U	R	U	U	R	–	–	U	–	–	–	–	U	–	–	G	E	–	G	G	–	–
Butyl Phthalate	–	–	U	R	R	–	R	R	R	–	R	B	A	D	U	–	A	–	C	–	–	G	G	–	G	U	G	G
Butylacetate	U	A	X	R	A	R	X	A	U	U	B	B	A	X	U	–	U	U	U	–	R	G	G	G	G	E	G	G
Butyric Acid	U	A	U	R	U	U	R	R	U	U	A	B	A	U	U	–	U	U	B	–	R	G	G	U	E	G	G	G
Carbon Tetrachloride	U	B	U	R	X	U	U	R	U	U	R	U	A	U	U	U	U	B	A	A	R	E	E	G	E	U	G	E
Carbonic Acid	R	B	A	R	R	R	A	A	R	R	A	B	A	X	X	R	A	–	A	A	–	G	G	G	E	E	G	G
Chloroacetic Acid	U	U	U	R	U	U	C	A	R	R	A	B	A	U	U	U	U	A	U	–	–	U	U	U	E	U	U	U
Chlorobenzene	U	X	U	R	R	U	U	B	U	U	A	U	A	U	U	–	U	A	A	A	R	G	G	G	E	G	G	G
Chlorobromomethane	–	–	–	–	C	–	A	A	U	–	–	B	–	U	U	–	U	–	A	A	–	–	–	–	–	–	B	–
Chlordane (¼ lb./gal.)	U	–	–	–	–	–	–	R	–	–	–	U	–	C	B	–	U	–	A	–	–	G	G	G	–	–	–	–
Chloroethane	U	A	U	R	R	R	X	A	U	U	A	X	A	U	U	–	U	–	B	–	–	G	G	G	–	–	–	G
Chloroform	U	A	U	R	R	U	X	A	U	U	A	U	B	U	U	U	U	B	A	A	R	E	E	U	G	G	G	G
Chloronaphthalene	U	–	–	–	–	–	–	–	R	–	–	–	–	U	U	–	–	–	–	–	–	–	G	–	E	U	–	–
Chlorophenol 5% (aq.)	–	R	U	R	U	–	–	R	U	U	R	–	–	–	–	–	–	–	–	–	–	G	G	S	E	–	–	–
Citric Acid	U	B	B	R	R	A	A	A	R	–	A	A	A	A	A	–	A	–	A	A	R	E	E	U	E	E	–	E
Cresol	U	U	U	R	U	U	U	R	X	U	R	U	A	U	U	U	U	U	X	–	R	E	G	G	G	G	–	–
Cresylic Acid 50%	U	U	U	R	U	R	X	R	R	R	R	X	–	U	U	U	U	–	A	–	–	G	G	G	G	G	–	–
Crude Oil	R	R	R	R	R	U	R	U	U	U	U	U	–	U	R	R	–	–	R	–	–	E	E	G	E	E	G	G
Cyclohexane	R	A	U	R	R	R	U	A	X	–	R	U	A	U	B	R	U	U	A	–	–	G	G	G	G	G	G	G
Cyclohexanone	U	A	U	R	R	U	U	A	U	U	R	B	U	U	U	–	U	U	U	A	–	G	G	U	G	G	G	G
DDT 5%	–	–	U	–	–	–	–	–	U	U	–	–	–	–	–	–	–	–	–	–	–	E	E	G	–	E	–	–
Detergents (general)	B	A	A	R	R	R	A	A	R	R	A	A	A	B	A	–	A	A	A	A	–	E	G	G	E	G	G	E
Diacetone Alcohol	–	A	U	R	R	R	R	A	R	–	A	A	B	U	U	–	U	B	U	–	–	G	G	G	E	E	E	E
Dibutyl Phthalate	U	–	U	R	R	U	R	R	U	U	U	R	–	U	U	U	–	–	U	–	–	G	G	G	G	G	G	G
Dichlorobenzene	U	–	U	R	X	U	C	A	U	U	A	U	–	U	U	–	U	–	C	–	–	–	G	–	E	G	–	–
Dichloroethane	U	A	U	R	R	R	X	A	U	U	A	U	A	U	U	–	–	U	C	A	R	G	G	G	G	G	G	–
Dichloroethylene	U	–	–	R	R	–	R	R	U	U	R	U	–	U	U	–	–	–	R	–	–	G	G	–	G	G	–	–
Dichlorofluoromethane	–	–	–	R	–	–	–	R	U	U	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diesel Fuel	–	A	A	R	R	R	A	A	R	–	A	U	A	B	A	–	U	–	A	–	–	E	E	G	G	E	E	–
Diethanolamine	–	–	–	R	R	–	R	R	U	U	U	–	–	R	–	–	–	–	–	–	–	E	E	E	E	E	–	G
Diethyl Amine	U	B	U	R	R	U	A	X	U	–	X	B	A	A	C	–	B	C	A	–	–	G	G	U	–	G	–	–
Diethyl Ether	U	R	U	R	R	U	R	A	U	U	R	U	C	U	U	–	U	–	U	–	–	G	G	G	G	G	G	G
Diethyl Phthalate	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diethylene Glycol	B	A	A	R	R	R	A	A	X	–	A	A	–	A	A	–	B	C	A	–	–	E	E	E	G	G	–	G
Dimethyl Aniline	U	U	U	R	R	–	X	A	U	U	A	B	A	U	U	–	U	U	U	–	–	B	B	–	B	A	–	–
Dimethyl Ether	–	–	–	R	–	–	–	R	–	–	–	–	–	U	R	–	–	–	–	–	–	G	G	–	G	–	G	G
Dimethyl Formamide	U	X	U	R	R	R	A	X	U	U	U	X	A	X	U	–	C	U	X	–	–	–	G	U	–	E	–	–
Dimethyl Phthalate	U	–	–	R	R	–	R	R	U	U	R	–	–	U	U	–	–	–	R	–	–	E	E	E	–	E	–	–
Dimethyl Sulfoxide	–	R	U	R	R	R	R	R	U	–	U	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dinitrotoluene	–	–	–	–	–	–	–	R	–	–	–	U	–	U	U	–	U	–	X	–	–	G	G	–	–	–	–	–
Dioctyl Phthalate	U	–	U	R	R	U	U	R	U	U	R	R	–	U	U	U	–	–	R	–	–	G	G	G	–	E	–	–
Dioxane	U	R	–	R	R	U	R	R	U	–	U	U	–	U	U	–	–	–	U	–	–	G	G	G	G	G	G	G
Diphenyl	–	–	–	R	R	–	U	A	U	–	–	U	–	B	U	R	U	–	A	–	–	G	G	G	G	G	G	G
Diphenyl Oxide	–	U	–	–	–	–	U	A	U	–	B	U	–	U	A	–	C	U	A	–	–	B	A	–	B	B	–	A
Esters (general)	–	–	U	R	R	–	–	R	U	U	R	–	–	–	–	–	–	–	–	–	–	–	G	–	–	–	–	–

REFERENCE PAGES

	Plastics											Elastopolymer										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon®)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon®	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Ethane	–	A	A	–	U	–	U	A	A	–	A	U	–	B	A	–	U	A	A	–	–	A	A	–	–	–	–	A
Ethanolamine	–	U	U	R	R	–	X	A	U	–	X	B	U	B	B	–	B	–	U	A	–	E	E	G	G	G	–	–
Ethers (general)	U	A	U	–	R	U	U	A	U	U	R	C	B	U	X	–	U	C	X	–	R	E	E	G	G	G	G	G
Ethyl Acetate	U	A	U	R	R	R	A	A	U	U	X	B	A	U	U	U	B	U	U	A	R	G	G	G	G	–	G	G
Ethyl Alcohol	B	A	B	R	R	R	A	A	R	R	R	A	B	A	C	U	B	C	A	A	R	G	G	G	E	E	G	G
Ethyl Benzene	–	R	–	R	–	U	U	R	U	U	R	U	–	U	U	–	–	–	R	–	–	S	G	U	E	G	–	–
Ethyl Benzoate	U	–	U	–	–	U	B	A	U	–	U	–	–	U	U	–	U	U	A	–	–	–	–	–	–	–	–	–
Ethyl Chloride	U	R	U	R	R	U	U	R	U	U	R	R	–	U	R	U	–	–	B	–	R	E	E	G	G	–	–	G
Ethyl Ether	U	A	U	R	R	U	U	A	U	U	R	U	A	U	X	U	U	–	U	–	R	G	G	G	G	G	G	G
Ethyl Sulfate	–	–	–	–	–	–	–	A	–	–	–	–	A	–	A	–	–	–	A	–	–	U	U	–	–	–	–	B
Ethylene Bromide	U	–	U	R	R	U	U	A	U	U	A	X	B	X	U	–	U	U	A	–	–	E	E	–	E	–	–	–
Ethylene Chloride	U	A	U	R	R	R	X	A	U	U	A	X	A	U	U	–	U	–	B	–	–	G	G	G	–	–	–	G
Ethylene Chlorohydrin	U	U	U	R	U	U	X	A	U	U	A	B	–	X	U	U	C	U	A	–	–	G	G	G	G	G	G	G
Ethylene Diamine	U	X	U	R	U	–	R	A	U	U	B	A	U	X	A	–	A	–	B	–	–	G	G	G	U	G	U	U
Ethylene Dibromide	–	–	–	R	–	–	R	R	–	–	R	–	–	–	–	–	–	–	–	–	–	–	G	–	G	–	G	–
Ethylene Glycol	A	B	A	R	R	R	A	A	R	R	A	A	A	A	A	R	A	B	R	A	–	G	G	G	E	E	G	G
Ethylene Oxide	U	U	X	R	R	R	U	A	U	U	A	X	C	U	U	U	U	–	U	–	R	G	G	G	E	E	U	–
Formaldehyde 100%	B	A	A	–	U	–	C	A	A	–	A	A	A	C	C	–	B	B	U	–	–	C	A	–	A	A	–	A
Formaldehyde 37%	A	A	A	R	R	R	A	A	R	R	A	A	A	B	X	U	–	–	R	–	R	E	E	U	G	G	E	G
Formic Acid 5%	–	U	R	R	U	R	R	R	R	–	R	R	–	R	U	–	–	–	R	–	–	G	E	–	E	U	S	E
Fuel Oils	U	A	–	R	R	R	A	B	R	R	B	U	A	B	X	R	U	A	A	–	–	G	G	G	G	G	G	G
Gasoline (high-aromatic)	U	B	A	–	–	–	A	B	A	–	A	U	A	A	A	–	U	A	A	A	–	A	A	–	A	U	–	–
Gasoline (leaded)	U	A	U	R	R	U	X	A	R	–	A	U	A	B	A	R	U	C	A	A	–	G	G	G	E	G	G	G
Gasoline (unleaded)	U	A	X	R	R	U	X	A	R	–	A	U	A	B	A	R	U	C	A	–	–	G	G	G	E	G	G	G
Glycolic Acid	B	A	A	R	–	R	A	A	R	R	B	A	B	A	A	–	A	A	A	–	–	G	G	U	G	G	–	–
Heptane	X	A	A	R	R	R	C	A	R	R	A	U	A	B	A	U	U	B	A	–	–	G	G	G	E	G	G	G
Hexachloroethane	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	G	G	–	G	G	S	G
Hexamine	–	–	–	R	–	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	E	E	–	E	E	G	–
Hexane	U	A	B	R	R	U	B	A	R	R	A	U	A	B	A	R	U	U	A	–	–	E	E	G	E	G	G	–
Hexyl Alcohol	–	A	–	–	A	–	–	A	A	–	–	C	–	A	A	–	B	A	C	–	–	A	A	–	A	A	–	–
Hydraulic Oil (petro.)	–	B	–	–	A	–	U	A	A	–	A	U	–	A	A	–	B	A	A	–	–	A	A	–	A	A	A	A
Hydraulic Oil (synthetic)	–	–	–	–	A	–	U	A	A	–	A	A	–	A	U	–	B	A	A	–	–	A	A	–	A	A	A	A
Hydrazine	–	B	U	–	–	U	C	C	–	–	A	A	–	B	B	–	B	–	A	–	–	A	A	–	–	–	–	A
Hydrogen Peroxide (dilute)	R	R	U	R	R	R	R	R	R	–	R	R	–	U	R	–	–	–	R	–	–	G	G	U	E	E	U	U
Hydroquinone	X	A	A	R	U	–	A	A	R	R	R	U	–	A	X	–	–	–	B	–	–	G	G	G	G	G	G	–
Hydroxyacetic Acid 70%	–	A	A	–	–	–	–	A	U	–	A	A	–	A	A	–	–	–	A	–	–	–	–	–	–	–	–	–
Iodoform	–	–	–	R	–	–	R	C	–	–	C	A	–	A	U	–	–	C	R	–	R	E	E	U	U	G	–	G
Isobutyl Alcohol	B	A	–	–	A	–	A	A	A	–	–	A	–	A	B	–	A	A	A	–	–	–	–	–	–	–	–	–
Isooctane	–	–	–	–	A	B	A	A	A	–	A	U	A	B	A	–	U	A	A	–	–	A	A	–	–	A	A	–
Isopropyl Acetate	U	U	U	R	R	R	B	A	U	U	X	B	–	U	U	–	U	–	U	–	–	E	G	E	G	G	–	–
Isopropyl Alcohol	R	A	C	R	U	R	A	A	R	R	R	A	–	B	B	U	A	A	A	A	–	G	G	G	G	G	G	G
Isopropyl Ether	–	U	R	R	R	–	X	A	R	R	X	U	A	U	B	R	U	A	U	–	–	E	G	–	–	–	G	G
Isotane	–	–	–	–	U	–	U	–	A	–	A	–	–	U	A	–	–	–	–	A	–	–	–	–	–	U	–	–
Jet Fuel JP–4, JP–5	–	A	R	R	R	–	A	A	R	R	A	U	A	U	A	U	U	A	A	–	–	G	G	G	E	G	E	–
Kerosene	X	A	R	R	R	R	R	A	R	R	A	U	A	A	A	U	U	U	A	A	–	G	G	G	G	G	G	G
Lacquer Thinners	A	U	–	–	A	–	U	A	U	–	–	U	–	U	U	–	U	U	U	–	–	–	G	–	–	G	–	–
Lacquers	A	U	–	–	A	–	U	A	U	–	U	U	–	U	U	–	U	A	U	–	–	E	E	–	–	–	–	–
Lactic Acid	U	B	A	R	R	–	B	A	R	R	B	A	A	A	X	–	A	A	A	A	–	G	G	U	G	G	G	G
Lead Acetate	B	B	A	R	R	R	A	A	R	R	A	A	A	A	B	–	A	B	U	A	–	G	G	U	G	U	U	G

	Plastics											Elastopolymer										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon®)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon®	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Linoleic Acid	A	B	A	R	U	U	B	A	R	R	A	U	–	U	B	–	B	A	B	–	–	G	G	U	G	G	U	U
Maleic Acid	R	A	A	R	X	R	R	A	R	R	A	X	–	U	U	–	–	C	A	–	R	G	G	U	G	–	G	–
Malic Acid	R	A	R	R	X	R	A	A	R	R	A	U	–	X	A	–	B	A	A	–	–	E	E	U	G	G	–	U
Melamine	–	A	A	–	A	–	A	A	U	–	–	A	–	U	C	–	C	U	A	–	–	–	U	–	–	–	–	–
Methane	–	A	–	R	R	–	A	A	R	R	A	X	–	B	A	–	U	–	A	–	–	E	E	G	E	E	E	G
Methyl Acetate	U	X	U	R	R	R	X	A	U	U	B	X	A	X	U	–	U	A	U	–	–	G	G	S	E	G	–	–
Methyl Acetone	–	U	–	–	A	–	–	A	U	–	U	A	–	U	U	–	–	A	U	–	–	A	A	–	–	A	A	–
Methyl Acylate	–	B	–	–	–	–	U	–	–	–	B	B	–	B	U	–	U	–	U	–	–	A	–	–	–	–	–	–
Methyl Alcohol	U	A	A	R	R	R	A	A	R	R	A	A	A	A	A	U	A	A	U	A	R	G	G	G	E	G	G	G
Methyl Alcohol 10%	U	A	A	–	B	B	A	A	–	–	A	A	A	A	A	–	A	A	A	A	–	–	–	–	–	–	–	–
Methyl Amide	U	U	–	–	–	–	A	A	U	–	C	A	A	–	B	–	–	U	U	–	–	A	A	–	–	A	U*	–
Methyl Bromide	U	U	U	R	U	R	X	A	U	U	A	U	–	U	B	–	–	–	A	–	–	G	G	G	–	U	–	–
Methyl Butyl Ketone	–	U	–	–	U	U	U	–	–	–	U	A	–	U	U	–	U	–	U	–	–	A	A	–	–	–	–	–
Methyl Chloride	U	B	U	R	R	U	U	A	U	U	A	U	A	U	U	U	U	U	A	–	–	E	E	U	G	U	E	G
Methyl Chloroform	U	–	U	R	–	–	U	R	U	U	R	U	–	U	U	–	–	–	R	–	–	–	–	–	–	–	–	–
Methyl Dichloride	–	U	–	–	C	–	U	–	–	–	U	U	–	–	U	–	–	–	A	–	–	–	–	–	–	–	–	–
Methyl Ethyl Ketone	U	U	U	R	R	U	B	A	U	U	U	A	A	U	U	U	U	U	U	A	–	G	G	G	G	G	G	G
Methyl Isopropyl Ketone	–	–	–	–	A	–	–	A	U	–	–	C	–	U	U	–	C	–	U	–	–	A	A	–	–	A	–	A
Methyl Methacrylate	–	U	R	R	–	–	X	R	R	U	B	U	–	U	U	–	C	–	U	–	–	G	G	U	–	G	–	–
Methyl Pentanone	U	–	U	R	R	R	R	A	U	U	X	B	A	U	U	–	U	–	U	–	–	G	G	G	G	G	G	G
Methylene Chloride	U	B	U	R	U	U	B	A	U	U	B	X	A	U	U	U	–	U	B	–	R	G	G	G	E	E	G	G
Monochloroacetic Acid	–	U	–	–	U	U	–	A	–	–	B	C	B	A	U	–	–	–	C	–	–	A	A	–	A	U*	B	U*
Monoethanolamine	–	U	–	R	R	–	B	A	U	U	U	B	–	X	B	–	B	–	X	–	–	E	E	G	G	G	G	G
Motor Oil	C	B	A	R	R	U	U	A	R	R	B	U	A	B	A	–	–	A	R	A	–	G	G	G	–	–	G	G
Napthalene	U	X	U	R	R	U	R	A	U	U	A	U	A	U	U	R	U	C	A	A	–	E	E	G	G	G	G	G
Nitrobenzene	U	X	U	R	R	U	B	A	U	U	A	U	A	U	U	U	U	U	B	–	R	G	G	G	G	E	G	G
Nitromethane	U	A	U	R	U	–	R	A	R	R	A	B	A	U	U	–	U	B	U	–	–	G	G	G	–	G	–	–
Nitrophenol	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	G	G	–	–	G	–	G
Octane	–	–	–	R	–	R	R	R	U	U	R	U	–	R	R	–	–	–	R	–	–	–	G	G	–	G	G	G
Octyl Alcohol	A	A	B	–	A	–	–	–	–	–	–	B	–	B	B	–	B	–	B	–	–	A	A	–	C	A	–	A
Oleic Acid	X	A	A	R	R	U	B	A	R	R	A	B	B	X	B	R	U	C	B	A	–	E	E	G	G	G	S	G
Oxalic Acid 5%	R	U	R	R	U	R	R	R	R	R	R	R	–	R	U	–	–	–	R	–	–	U	G	U	G	G	S	G
Palmitic Acid 10%	A	A	A	R	R	R	B	A	R	R	A	B	–	U	A	R	U	B	A	–	–	–	G	–	–	G	G	G
Pentachlorophenol	–	–	–	–	–	–	–	R	–	–	–	–	–	–	–	–	–	–	R	–	–	–	–	E	–	–	–	–
Pentane	–	B	–	–	A	–	U	A	A	–	A	U	–	B	A	–	U	A	A	–	–	C	C	–	A	B	–	–
Petroleum	B	B	A	R	–	U	B	A	R	–	A	U	–	B	A	–	U	–	A	–	–	G	G	–	–	G	G	G
Phenol 10%	U	X	A	R	U	R	B	A	U	U	A	B	B	U	U	U	U	C	A	A	–	G	G	G	G	E	G	G
Phthalic Acid	B	C	X	R	R	–	A	A	U	U	A	A	–	A	U	–	B	–	A	–	–	G	E	S	G	G	G	G
Phthalic Anhydride	B	C	U	R	–	–	U	A	U	–	A	A	–	A	U	–	–	B	A	–	–	E	E	G	E	E	G	–
Picric Acid	X	A	U	R	U	U	A	A	U	U	A	A	–	A	X	–	B	–	A	–	R	G	G	U	G	E	U	U
Propyl Alcohol	X	A	A	R	U	R	A	A	R	R	A	A	A	A	A	–	A	A	A	A	–	E	E	G	E	G	G	G
Propylene	B	–	–	–	–	–	–	A	B	–	–	U	–	U	U	–	U	B	A	–	–	B	A	–	–	A	–	A
Propylene Glycol	B	B	X	R	R	R	A	A	U	U	A	A	–	C	A	–	A	–	A	A	–	G	G	G	G	G	G	G
Propylene Oxide	–	–	–	R	–	R	R	R	U	U	U	R	–	U	U	–	–	–	U	–	–	E	E	–	–	–	–	–
Pyridine	–	B	U	R	R	R	A	A	U	U	U	X	A	U	U	–	U	U	U	A	–	G	G	G	E	G	G	G
Sodium Acetate	B	B	A	R	R	R	A	A	R	R	A	A	A	B	B	–	U	–	U	A	–	G	G	U	G	E	G	G
Sodium Benzoate	A	–	A	R	R	R	A	A	R	R	A	A	–	A	B	–	–	B	A	–	–	–	–	–	G	G	–	E
Sodium Hypochlorite 20%	R	U	R	R	U	R	R	R	R	R	R	R	A	U	U	–	B	C	A	–	U	U	U	U	U	G	G	S
Stearic Acid	U	A	B	R	R	R	A	A	R	R	A	X	–	B	B	R	B	B	A	–	R	G	E	S	E	G	S	G

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	Plastics											Elastopolymer										Metals						
	ABS	Acetal (Delrin)	CPVC	FEP	Nylon 6, 66	HDPE	Polypropylene	PTFE (Teflon®)	PVC Type I	PVC Type II	PVDF (Kynar)	EPDM	Kel-F	Neoprene	Nitrile Buna-N	Polyurethane	Silicone	Tygon®	Viton-A	Ceramic	Silica	304 Stainless	316 Stainless	Carbon Steel	Hastelloy-C	Aluminum	Brass	Copper
Styrene	–	A	U	–	A	U	–	A	U	–	–	U	–	U	U	–	U	–	B	–	–	A	A	–	U*	A	A	B
Tartaric Acid	–	B	A	–	B	–	A	A	A	–	B	B	A	A	A	–	A	B	A	A	–	C	C	–	B	B	U*	A
Tetrachloroacetic Acid	R	–	R	R	R	R	R	R	R	R	R	U	–	R	R	R	–	–	R	–	–	E	E	–	G	G	S	U
Tetrachloroethane	–	A	X	R	R	–	C	A	U	U	A	U	A	U	U	–	U	–	A	–	R	E	E	E	E	G	–	S
Tetrachloroethylene	U	A	U	R	R	U	U	A	U	U	R	U	A	U	U	U	U	–	A	–	–	E	E	G	G	G	G	G
Tetrachlorophenol	–	–	–	–	–	–	R	R	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tetraethyl Lead	U	–	R	R	–	U	R	R	R	R	R	U	–	–	U	–	–	–	R	–	–	G	G	G	–	G	G	–
Tetrahydrofuran	U	A	U	R	R	U	C	A	U	U	B	U	A	U	U	–	U	–	X	A	–	E	G	E	E	U	–	–
Toluene	U	X	U	R	R	U	C	A	U	U	A	U	B	U	X	U	U	U	C	A	–	E	E	E	E	E	E	E
Toxaphene-Xylene 10-90%	–	–	U	R	–	–	R	R	U	–	–	–	–	–	–	–	–	–	–	–	–	G	G	S	–	S	–	–
Trichloroacetic Acid	–	–	R	R	U	R	A	A	R	–	B	B	A	U	R	–	U	C	C	A	–	U	U	U	G	U	G	G
Trichlorobenzene	–	–	–	–	–	–	–	R	U	–	–	–	–	U	U	U	–	–	R	–	–	–	–	E	–	–	–	–
Trichloroethane	–	A	–	–	–	–	C	A	C	–	A	U	A	U	U	–	U	–	A	–	–	–	–	–	–	–	–	–
Trichloroethylene	U	U	U	R	R	U	C	A	U	U	B	U	A	U	U	U	U	–	X	A	–	G	G	G	E	E	G	G
Trichlorofluoromethane	–	–	–	–	–	–	–	–	U	–	–	–	–	U	U	–	–	–	–	–	–	–	G	–	–	G	–	–
Trichloropropane	U	A	–	–	–	–	–	A	–	–	–	–	A	A	U	–	–	U	A	–	–	A	A	–	A	U*	–	A
Triethanolamine	R	U	R	R	R	U	R	R	U	U	R	R	–	R	U	U	–	–	R	–	–	G	G	G	G	G	U	E
Triethylamine	U	U	A	R	R	–	U	A	R	R	A	A	A	A	C	–	–	A	X	B	–	G	G	–	–	–	–	–
Trimethylpropane	U	–	R	R	–	–	U	R	R	R	R	–	–	–	R	R	–	–	–	–	–	–	–	–	–	–	–	–
Turpentine	U	A	A	R	R	U	X	A	X	U	A	U	A	U	R	U	U	B	A	A	–	E	E	G	G	G	S	G
Vinyl Acetate	U	–	U	R	–	U	B	A	U	U	A	B	–	X	X	–	U	U	A	B	–	E	E	G	E	E	G	–
Vinyl Chloride	U	–	U	–	A	–	–	A	U	–	B	C	–	U	U	–	–	U	A	A	–	B	A	–	A	B	–	B
White Liquor (pulp mill)	X	U	R	R	R	–	R	R	R	R	R	R	–	R	R	–	–	–	R	–	–	G	G	S	G	G	–	–
White Water (paper mill)	R	B	–	–	R	–	R	–	R	–	–	–	–	A	–	–	–	–	A	–	–	A	A	–	–	–	–	–
Xylene	U	A	U	R	R	U	B	A	U	U	A	U	A	U	U	U	U	U	X	A	–	G	G	G	E	G	G	G

This table should only be used as a guide since it is difficult to duplicate operating conditions. To fully guarantee the suitability of a particular material, chemical resistance tests should be conducted under actual operating conditions.

No data was found on the following environmentally important chemicals:

Acenaphthene*
Acenapthalene*
Acrolein
Anthracene*
Benzidine
Benzo(a)athracene*
Benzo(b)fluoranthene*
Benzo(g,h,i)perylene*
Benzo(a)pyrene*
Bromophenylphenylether
Butylbenzylphthalate
Chlorodibromomethane
Chloroethoxymethane
Chloroethylether
Chloroethylvinylether
Chloroisopropylether
Chloromethylether
Chlorophenylphenylether
Chrysene*
DDD**
DDE**
Dichlorobenzidine
Dichlorobromomethane
Dichlorophenol
Dichlorophenoxyacetic Acid
Dichloropropane
Dichloropropylene
Dieldrin**
Dinitrophenol
Diphenylhydrazine
Endosulfan
Endrin**
Fluoranthene*
Fluorene*
Heptachlor**
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclohexane
Indeno(1,2,3–c,d)pyrene*
Isophorone
2–Methylnapthalene
Parachlorometa Cresol
Phenanthrene*
Phenylenepyrene
Pyrene*
Trichlorophenol
Trichlorophenoxyacetic Acid

* Component of cresotoe and coal tar. At room temperature and below, these compounds are solid in pure form.
** Pesticides